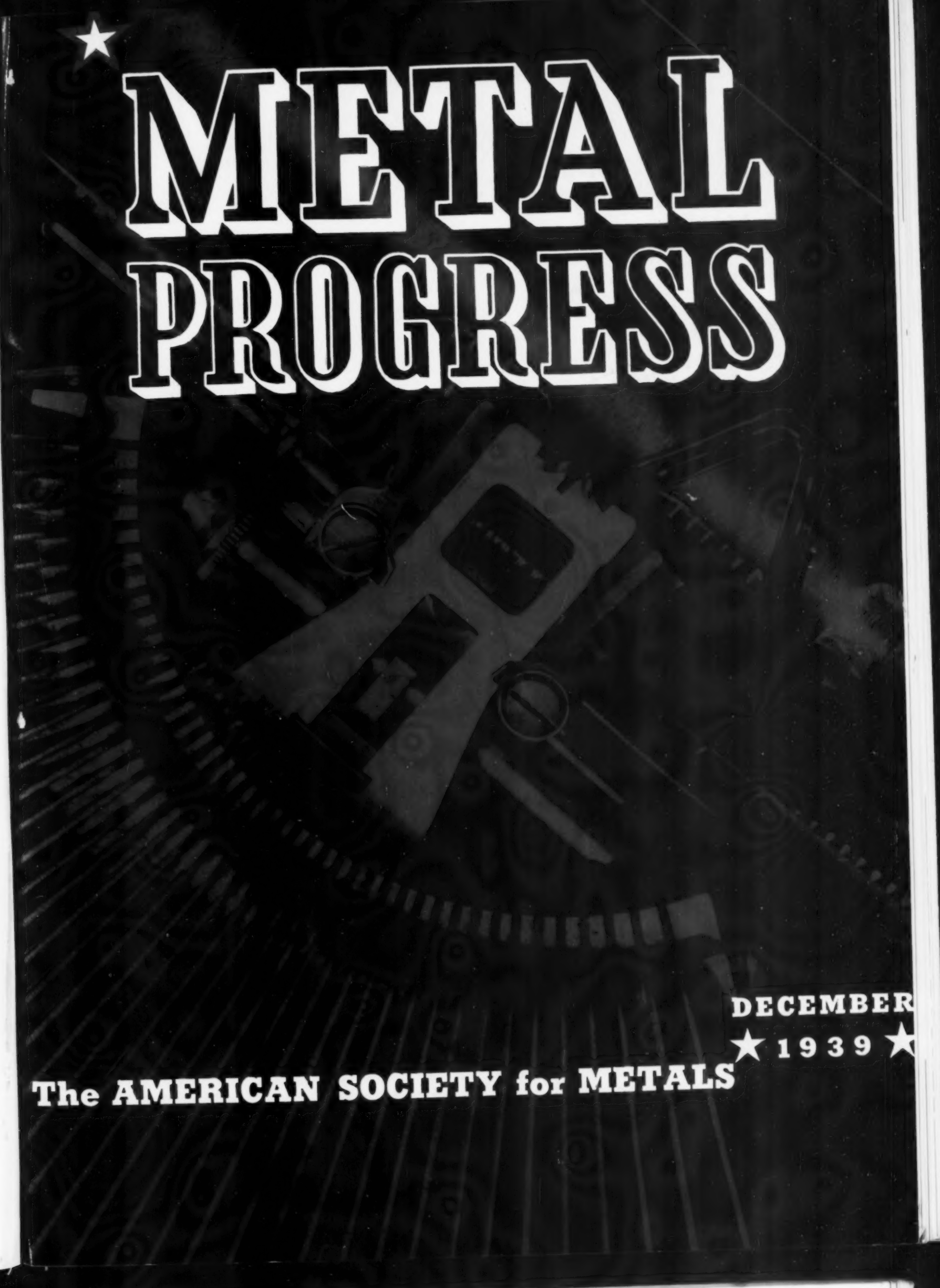
METAL PROGRESS



DECEMBER
★ 1939 ★

The AMERICAN SOCIETY for METALS

TAKE THE "GUESS" OUT OF HEAT TREATING WITH..

SC STANDARD FURNACES

RATED

A very outstanding feature of SC Standard Furnaces is that they are *rated*. With the aid of simple charts and curves listed with each furnace, you yourself can *predetermine* every important factor—such as gas consumption, time to heat a cold or warm furnace to temperature, time to heat a load with the furnace at temperature—in fact, you can determine every important factor influencing production and costs—before starting the job—you can take the guess out of heat treating.

Many concerns make it a practice to keep a detailed analysis of each individual furnace heat so that the results can either be duplicated or bettered on a subsequent heat. However, often to their dismay identical settings do not produce identical results.

This is caused by varying air-gas ratios common to burner equipment not provided with automatic proportioning inspirators for mixing the air and gas. Incorrect mixtures of air and gas retard the rate of heating, cause scale and decarburization, resulting in fuel losses often amounting to as much as 50%.

With SC Standard Rated Furnaces you can be certain that identical settings will produce identical results. SC inspirators are automatic proportioning and only *one valve* is required for adjustments. The air-gas ratio is automatically maintained and can be adjusted to constantly maintain any desired atmosphere, reducing, neutral or oxidizing.

SC Standard Rated Gas-Fired Furnaces are available in a large variety of different types and sizes. There is a correct SC Standard Rated Furnace to meet your exacting requirements. Ask for Catalog.

SURFACE COMBUSTION CORPORATION..Toledo, Ohio.

Builders of ATMOSPHERE FURNACES and HARDENING, DRAWING, NORMALIZING, ANNEALING FURNACES for CONTINUOUS or BATCH OPERATIONS

SURFACE SC COMBUSTION

CONTINUOUS HARDENING OF STEEL BARS BY NEW TOCCO UNIT

Cuts Costs! Speeds Production!

✱ TOCCO'S new, continuous machine actually TOCCO hardens heavy duty steel bars, 1¾" x 9", at the rate of 33" per minute. Done at a fraction of the cost and time required for the previous method of carburizing, sizable savings have already been effected by one large user. The TOCCO continuous unit has replaced several carburizing furnaces.

Bars are hardened to 60-62 Rockwell "C". This high hardness is maintained through 80% of the depth of the hardened area which is .125". Service tests prove that these TOCCO hardened parts give longer life than previously used carburized parts.

This new TOCCO unit (56" high, 45" wide and 52" deep) fits a machining line easily . . . is adaptable to all cylindrical shapes . . . has fixtures that are quickly interchanged. Power is supplied by a motor generator set. Skilled operators are not required. ★

Write for full information on TOCCO'S most recent application of surface hardening by induction. Investigate the new, improved way to cut heat-treating costs.

For example—

MATERIAL: SAE 1050 steel—Ground
SIZE: 1¾" diameter x 9" long
HARDNESS: 60 to 62 Rockwell "C"
HARDENING COST: Only $8.00 per ton.

No Distortion — No Scaling
No Decarburization

THE OHIO CRANKSHAFT COMPANY
CLEVELAND, OHIO

Alloy Blooms, Billets and Bars
Carbon and Alloy Seamless Tubing
Tool and Fine Steels
Stainless Steels
—
Open Hearth and Electric Furnace Quality

GOOD WILL BASED ON GOOD STEEL

Man's earliest recognition of the value of steel as a life protector was in the making of body armor. Today millions owe their personal safety to the development of alloy steel and its use in the manufacture of automobiles, buses, airplanes and railway trains.

The progress made in the production of alloy steel in the United States during the last 25 years has made this period one of the most spectacular in the entire history of steel manufacture. Within this comparatively brief space of time, through the constantly increasing use of scientific methods of research and manufacture, TIMKEN Alloy Steel has risen to a position second to none in its field. The reputation for quality and uniformity which TIMKEN Steel and TIMKEN Seamless Steel Tubing have achieved merits the consideration of every steel user.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO
Steel and Tube Division

TIMKEN
ALLOY STEELS

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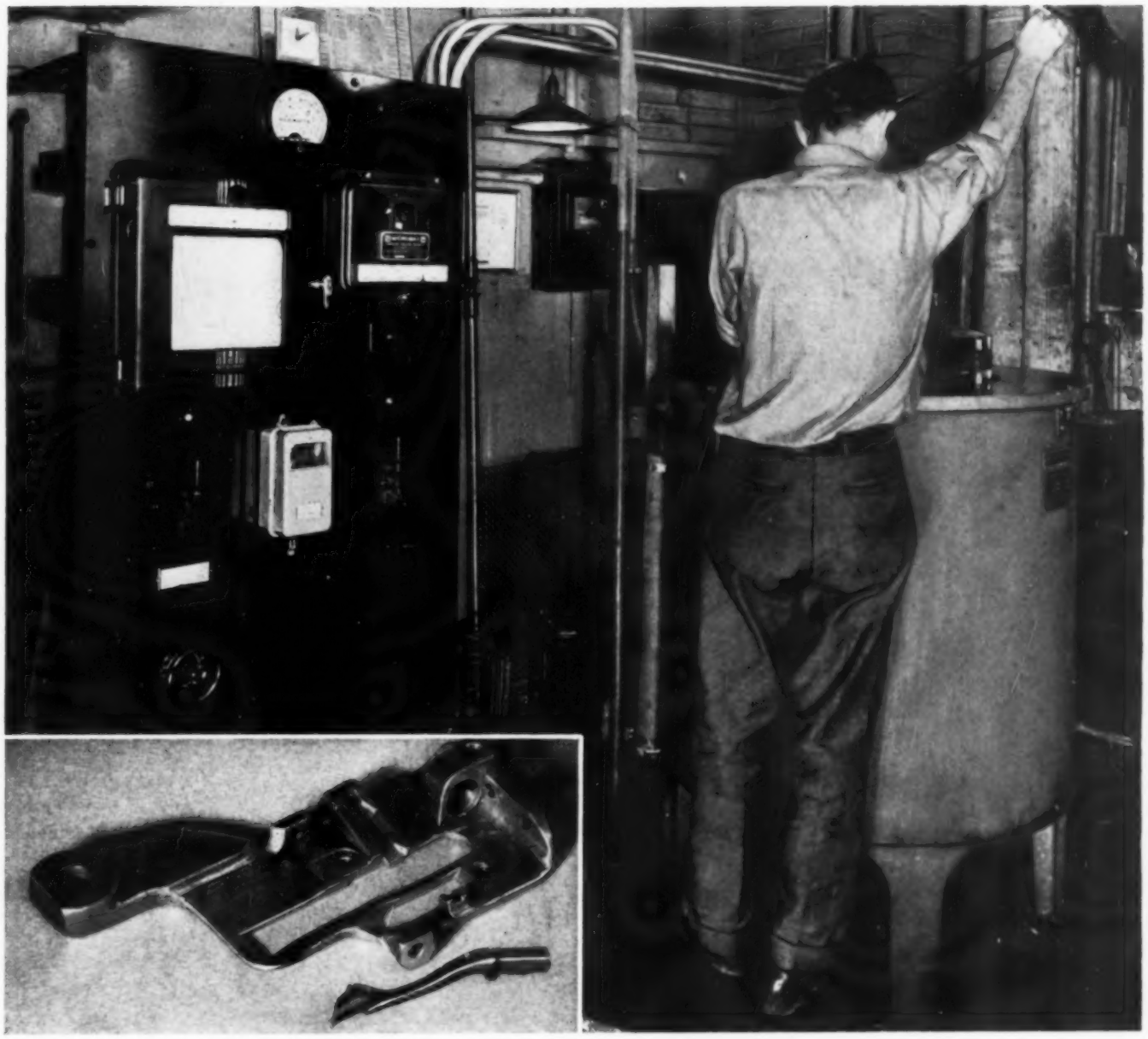

SCALE-FREE *Vapocarb* HARDENING

Used in the mechanism of the Lewis invisible-stitch sewing machine, these forged-steel parts are typical of hard-to-handle heat-treatment found in many plants.

After long experience, the Lewis company prefers Vapocarb-Hump hardening to any other method for this work. They have several reasons:

1. Rejects due to heat-treatment are almost unknown. Parts heat uniformly. Control is automatic. The well-known "Hump" on the chart shows the critical and helps the heat-treater quench for desired structure.

2. Parts are kept clean by the furnace's Vapocarb atmosphere. There's no scale or pitting; no soft spots; nothing to create rough surface or interfere with quench efficiency.

3. And—the record shows every important fact about furnace operation—rate of heating, critical, quench point. As long as this record is available, results can be duplicated at any time.

Write for Catalog T-621, "Vapocarb-Hump Hardening"

LEEDS & NORTHRUP COMPANY, 4927 STENTON AVE., PHILA., PA.

LEEDS & NORTHRUP

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

J-1 Ad T-621(25)

On the nose...

it's Bethlehem Alloy Steel

When United Air Line's new, larger sleeper planes go into service, passengers will find it difficult to tell when they have landed. For these giant DC-4's have the so-called tricycle landing gear; the tail never touches the ground; the passenger compartment always remains level.

The first heavy-duty tricycle landing gear—with a wheel under the nose instead of under the tail—was on the first Douglas DC-4. Bethlehem alloy steels were used in the construction of the carriage.

Bethlehem alloy steels are often used in "firsts." They were used in the *Spirit of St. Louis* and in Hughes' record-setting plane; they are being used in the Clippers. Such preference is the natural result of Bethlehem's half-century of experience in making alloy steels to handle specific tasks. You get the benefits of this long, intensive experience when you buy Bethlehem alloy steels.

BETHLEHEM STEEL COMPANY

BETHLEHEM STEEL

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Luther Burbank

"The Plant Wizard" of America. Known throughout the world for his remarkable success in improving the plant life of nature and creating new ones.

Acting upon his theory that "A weed was only a plant out of place," he developed them into plants whose flowers rivaled his most famous kinds in fragrance and beauty.

He added more wealth to the United States, than all the gold taken from the mines of California.

There is no leadership more lasting than his.

THERMALLOY the "EYE" of QUALITY
THE ELECTRO ALLOYS COMPANY
CASTINGS FOR HEAT CORROSION
ELYRIA, OHIO

PYRASTEEL
for longer Service
at high temperatures

Refinery fittings made of Pyrasteel No. 14

For moderate temperatures . . . up to 1500° F., . . . PYRASTEEL No. 14 has earned a high reputation as a thrifty alloy.

There are innumerable applications, where buyers feel that the more expensive alloys are not justified, but where carbon steel proves entirely inadequate. While PYRASTEEL No. 14 may be called an "in-between grade," it is by no means to be considered a *cheap* substitute.

The analysis of PYRASTEEL No. 14, both chemical and physical, is well known to engineers in many lines of industry . . . and is a standard material.

PYRASTEEL No. 14 is a material of high tensile strength with good resistance to corrosion, as well as to temperatures up to 1500° F. . . .and it is easily machinable.

• • • •

NOTE: Remember that PYRASTEEL also comes in other grades for applications up to 2200° F., and it has the highest tensile strength at high temperatures of any known alloy.

• • •

We have prepared an illustrated bulletin on PYRASTEEL No. 14, giving complete engineering data, which we shall be glad to send free on request.

Write for Your Copy

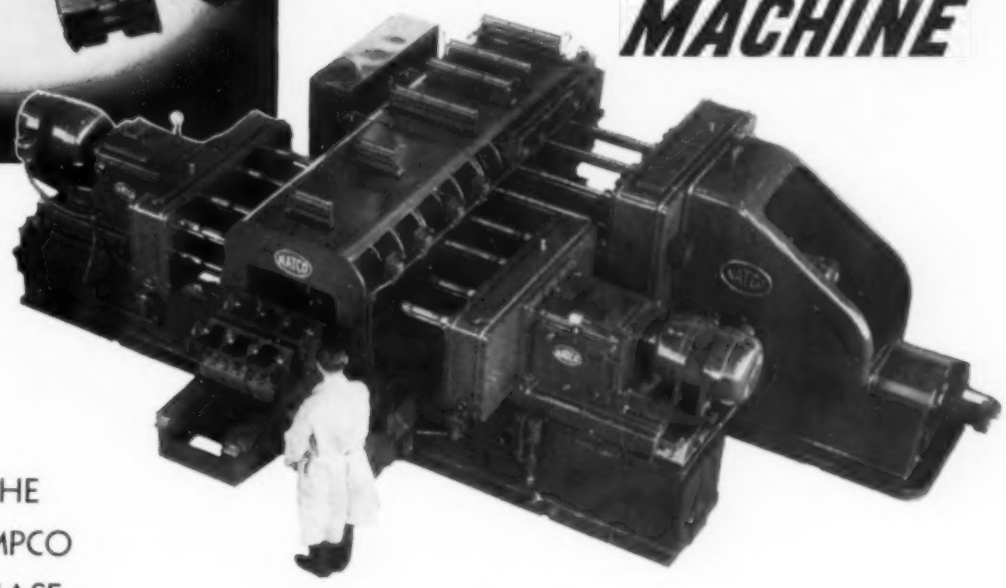
CHICAGO STEEL FOUNDRY CO.

Kedzie Avenue at 37th Street, Chicago, Ill.

MAKERS OF ALLOY STEELS FOR THIRTY YEARS

58 AMPCO METAL PARTS USED IN THIS NATCO MACHINE

These AMPCO METAL parts play an important role in the remarkable performance of the NATCO boring machine shown at right.



THE AMPCO PHASE

Through the alloying process and the "AMPCO PHASE", there is developed a structure which in actual service has proved high in wear-resistant qualities. Comparative tests reveal longer wearability, greater resistance to shock, and greater strength wherever stress and strain are involved. These properties processed in AMPCO METAL are not found in any other bronze.

IN this high speed NATCO machine which performs all the core drilling, rough, semi-rough and finish boring operations on the Welch plug holes and cam and crankshaft bearing holes — at the remarkable rate of 90 cylinder blocks per hour — a total of 58 AMPCO METAL parts are used to insure long life.

These 58 parts, with a Brinell hardness of 285-302, are used as guide bushings. AMPCO GRADE 21 is used wherever there is excessive speed between the bar and bushing, for AMPCO will not gall and seize as will steel — and yet it has the wear resistance necessary for holding exact tolerances over long periods of service.

File 40 — the bound volume of AMPCO Engineering Data Sheets — shows some noteworthy applications and characteristics of AMPCO METAL. It may solve a vital problem for you — write for File 40 today.

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AMPCO METAL

"The Metal without an Equal"

. . . distinguished by this mark.

Current Production Step-Up calls for "CARBOFRAX" HEARTHS

FOR years "Carbofrax" hearths have been famous for the way they speed up furnace operations and reduce costs. But now, with the current step-up in production, the advantages resulting from their high heat transfer are more important than ever. Every day more heat treating furnace operators are turning to "Carbofrax" hearths for

1. *Faster furnace operation—quicker "come-back"*
2. *Greater production from each furnace*
3. *Lower fuel cost per pound of metal heated*
4. *More uniform quality of work (bottom of work is heated at same rate as top)*

But that's not all! "Carbofrax" gives you these advantages, yes, and it *keeps on* giving them to you because of its long trouble-free life. If you want to step-up production and turn out better work at lower costs . . . if you want assured freedom from furnace interruptions and delays . . . be sure to insist on "Carbofrax" Hearths and Supports in new furnaces and for all replacements.

REFRACTORY CARBORUNDUM PRODUCTS

THE CARBORUNDUM COMPANY, REFRACTORY DIVISION, PERTH AMBOY, N. J.

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(Carborundum and Carbofrax are registered trade-marks of The Carborundum Company)

Advertisement

COPPER ALLOY BULLETIN

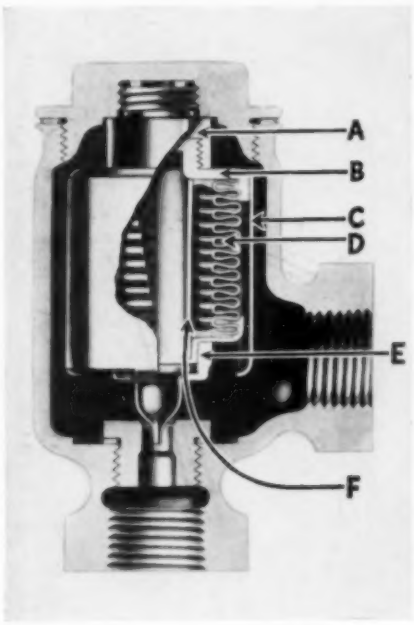
Reporting News and Technical Developments of Copper and Copper-Base Alloys

DECEMBER "Bridgeport" BRASS CO. 1939

STEAM TRAP PARTS SHOW ADAPTABILITY OF BRASS

The ease with which brass can be adapted to different fabricating processes for the production of a variety of shapes is admirably illustrated in the Thermo-Static Steam Traps manufactured by Sarco Company, Inc. These devices apply the principles of steam trapping to high pressure heating and industrial process work, and are used for pressures up to 200 pounds.

Part A in the photograph is made from round bar stock, B is pressed from sheet



metal, C and F are made from brass tubes. D is made from tubes and also from discs fabricated into tubes by Sarco. E is formed from hexagon bar stock.

Chromium Plating Method Produces Heavy Deposits

A new method for chromium plating is reported to be adapted for the production of heavy bright deposits. The method uses an aqueous solution containing about 250 grams of chromic acid and 1 to 5 grams of sulphate per liter. A current is passed to the article to be plated (which forms the cathode) at a density of at least 2 amperes per square inch. Temperature of the bath is maintained between 40 and 90 degrees C.

SPRING QUALITIES OF PHOSPHOR BRONZE GIVE WIDE ENGINEERING USEFULNESS

Strength, Ductility, Conductivity, and Corrosion Resistance Are Other Factors in Its Extensive Use in Many Applications

Notable among the copper alloys for its unique combination of desirable engineering properties, phosphor bronze is recognized as the most satisfactory alloy for many specialized applications.

The phosphor bronzes are alloys of copper and tin with small amounts of phosphorus. Two different compositions are given in the A.S.T.M. Specifications. The first is Phosphor Bronze A, containing 5% tin and 0.05 to 0.10% phosphorus, with the remainder copper. Phosphor Bronze C contains 8% tin, with the same amount of phosphorus as the A alloy. The phosphorus serves as a deoxidizing agent, just as it does in deoxidized copper, but it also increases the tensile strength.

Used for Spring Parts

The manufacture of spring parts is one of the outstanding applications of phosphor bronze. Here its high elasticity and resistance to fatigue under repeated bending are invaluable. Since phosphor bronze also has fair electrical conductivity, it is extensively used in switch and contactor parts, and fuse clips. Thermostatic bellows are another important use.

Other applications of phosphor bronze are the result of its high tensile strength, ductility, and resistance to corrosion by

The electrical industry is a large user of phosphor bronze. Spring qualities make this alloy especially suitable for such parts as fuse clips and spring contacts.

atmospheric conditions, dampness, and salt and acid waters. Such applications include bushings and valve parts. Still another extensive use is in paper-making machinery.

(Continued on Following Page, Column 2)

Self-Cleaning Shower Head Makes Copious Use of Brass

Novel idea in shower heads is the patented self-cleaning feature of the Anystream Head, manufactured by Speakman Company, Wilmington, Del. The Anystream Head never stops up. The conventional holes for the spray are replaced by a set of plungers that give normal or needle

showers at the turn of a handle. A further turn of the handle gives a floor spray that quickly washes away all sediment.

For long life in this unique head, Speakman Company uses brass. Outer section of the head is cast. The plungers, lever handle, the clips holding plungers to face plate, and the screws holding the face plate to the head are all made from brass rod.

Acetate and Thiosulphate Bath Colors Brass Blue

A blue color can be obtained on brass by using a solution of sodium thiosulphate and lead acetate, it is reported. Suggested quantities are 124 grams of thiosulphate and 38 grams of acetate for each liter of solution. The thiosulphate and the acetate are dissolved separately, each in a half-liter of water, and the two solutions are mixed just before use. Temperature of the bath should be about 60 degrees C., it is reported. A yellow-gold color is produced first, and is followed by the blue in about one-half minute.

COPPER ALLOY BULLETIN

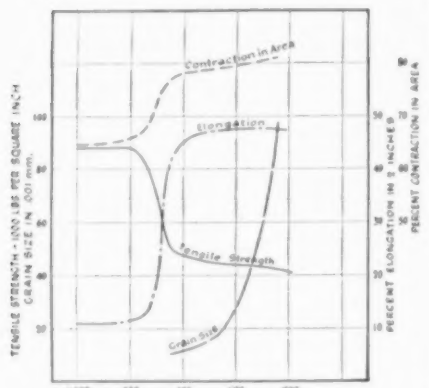
ALLOYS OF COPPER

This is the sixth of a series of articles on the properties and applications of the copper alloys, and continues the subject of Rich Low Brass.

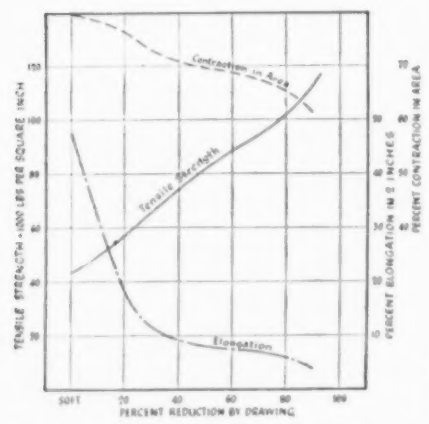
RICH LOW BRASS

The most important physical properties of Rich Low Brass (85-15) were listed in this column last month. Compared with Gilding Metal (95-5) or Commercial Bronze, Rich Low Brass is appreciably stronger and is hardened more rapidly by cold working. Other changes in properties, such as conductivity, coefficient of expansion, and density, vary more nearly in proportion to the increase in zinc content. Effects of cold working and annealing wire of this alloy are shown in the accompanying graphs.

The high strength and ductility of Rich Low Brass are accompanied by excellent resistance to failure by season cracking and dezincification. It is a combination of these properties that makes possible the use of this alloy in applications requiring the ability to withstand stresses without failure by deformation or corrosion.



Effect of Annealing on Mechanical Properties of 85-15 Copper-Zinc Alloys.



Effect of Cold Drawing on Mechanical Properties of 85-15 Copper-Zinc Alloys.

Wide Color Range Possible

The color of Rich Low Brass is also an important factor in its use. Alloys ranging between 82 and 88% copper show quite marked differences in color when the alloy is properly cleaned and polished. These slight differences in color have led to the use of several alloys of only slightly different copper content, depending upon the exact color desired. Most of such alloys find their use in the jewelry trade.

The alloy is also used to a considerable extent for water pipe and condenser tubes because of its resistance to dezincification and a slightly greater resistance to fatigue than high copper content alloys. Occasionally the alloy is modified slightly by the addition of small quantities of tin, in the belief that this increases the resistance to corrosion.

(The subject of Rich Low Brass will be concluded in next month's issue.)

Memos on Brass—No. 4

The composition of brass can be readily modified for specific requirements. The addition of lead, for example, results in a free-cutting alloy admirably adapted for high-speed automatic screw machine operation.

PHOSPHOR BRONZE USES

(Continued from Preceding Page, Column 3)

Bridgeport Brass Company, with its comprehensive manufacturing facilities, is in an excellent position to supply phosphor bronze of the high quality demanded by users of this versatile alloy. Its up-to-the-minute rolling equipment permits the use of larger bars for rolling sheet and strip. When these larger bars are used, the casting is sounder and more homogeneous—an especially important factor in the case of phosphor bronze. Bridgeport will be glad to discuss with prospective users the suitability of phosphor bronze for specific applications.

NEW DEVELOPMENTS

This column lists items manufactured or developed by many different sources. Further information on any of them may be obtained by writing Bridgeport Brass Company, which will gladly refer readers to the manufacturer or other source.

A turret lathe of a new design is intended especially for brass work, according to the manufacturer. It has a 16¾-inch swing and is designed for high-speed operation. It is provided with a direct two-speed drive, and is said to feature automatic control of the two spindle speeds and the reverse, which are operated by the movement and indexing of the hexagon turret.

A brightening agent is said to be suitable for addition to any standard nickel solution in order to produce a bright, lustrous deposit. It is said to work equally well in conveyors, plating barrels, or steel tanks. Brightness of the deposit is used as an indication of need for periodic additions of the brightener.

A rack coating is reported to air-dry much faster than the usual coatings. Dipping speed is about five times as fast, it is said. Coating is of low viscosity, producing thin coatings. According to the manufacturer, no tape or special treatment is needed for applying the coating.

A spray tank is especially designed for rinsing racked parts in electroplating. Alternate spray streams circulate both clockwise and counter-clockwise, and are interrupted by straight line streams to produce a multiplicity of spray eddies, it is reported. The maker claims that the method allows water savings ranging from 38 to 86 per cent and time savings up to 65 per cent.

A solder pot is designed for dipping small and delicate parts. Inside dimensions of unit are 2¾ by ½ by ⅜ inch deep. Solder capacity is said to be 2¾ ounces.

A tapping machine is air-controlled and has a capacity up to ⅜-inch diameter in brass. An automatic valve is said to control the speed with which the tap is fed into the work and reversed. Foot pedal starts and stops the tapping cycle, which is then controlled by the automatic valve.

A heavy-duty blowpipe is said to be designed for welding and heating ranges above those which can be handled by ordinary blowpipes. It is said to deliver intense heat to a localized area.

A new electrode is said to produce successful welds in non-ferrous metals. It consists of a tube threaded or tapered at bottom to take a standard welding tip, and a light inner tube of flexible copper braid, with provision for water-cooling attachments. It is reported that only the welding tip, the inner tube, and the water-cooling attachments are movable. This arrangement, says the maker, decreases the mass and friction of the moving part, and permits much more rapid movement of the electrode.

PRODUCTS OF THE BRIDGEPORT BRASS COMPANY

Executive Offices: BRIDGEPORT, CONN.—Branch Offices and Warehouses in Principal Cities

SHEETS, ROLLS, STRIPS—*Brass, bronze, copper, Duronze,** for stamping, deep drawing, forming and spinning.

CONDENSER, HEAT EXCHANGER, SUGAR TUBES—For steam surface condensers, heat exchangers; oil refineries, and process industries.

PHONO-ELECTRIC* ALLOYS—High-strength bronze trolley, messenger wire and cable.

WELDING ROD—For repairing cast iron and steel, fabricating silicon bronze tanks.

LEDRITE* ROD—For making automatic screw machine products.

COPPER WATER TUBE AND FITTINGS—For plumbing, heating, underground piping.

DURONZE ALLOYS—High-strength silicon bronzes for corrosion-resistant connectors, marine hardware; *hot rolled sheets* for tanks, boilers, heaters, flues, ducts, flashings.

BRASS, BRONZE, DURONZE WIRE—For cap and machine screws, wood screws, rivets, bolts, nuts.

FABRICATING SERVICE DEPT.—Engineering staff, special equipment for making parts or complete items.

BRASS AND COPPER PIPE—"Plumrite"* for plumbing, underground and industrial services.

BRASS "Bridgeport" CO.

Established 1865

*Trade-name.

BRIDGEPORT BRASS

Get UNIFORMLY *Bright Work*

G-E Atmosphere-Gas Converters Give You Consistent Results

INEXPENSIVE protective-atmosphere gases, *controlled to a high degree of uniformity regardless of demand*, are produced by G-E atmosphere-gas converters. Several hundred are now in use for bright-annealing, electric-furnace brazing, and scale-free hardening.

Types of Gases

G-E converters produce inert and reducing gases. Reducing mixtures have unusually high hydrogen and carbon-monoxide content; therefore, moisture removal is seldom required. Inert mixtures contain mostly nitrogen and CO_2. Oxygen content is zero.

Cost of Operation

The cost of these atmosphere gases is no more than ordinary gases from converters not equipped with input proportioning control—it is only a fraction of the unit cost of the fuel gas consumed by the converter.

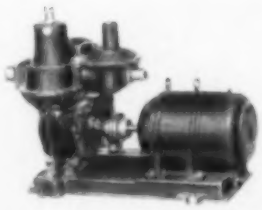
Other G-E Heating Equipments

G.E. can also supply accessories, such as refrigerators, dryers, sulphur removers, CO producer, CO-CO_2 conversion units, and CO_2 removers, in addition to a complete line of electric furnaces. Consult a G-E heating specialist—he will be glad to help you. General Electric, Schenectady, N. Y.

A COMPLETE LINE

G-E atmosphere-gas converters range in size from 200 to 25,000 cfh for use with coke-oven, natural, propane, or butane gases. For additional information, ask for the new G-E bulletin, GEA-2948.

4 Big Features of G-E Atmosphere-Gas Converters



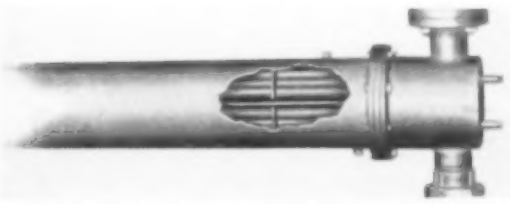
◀ **1. Gas-combustion Controller**—this device assures constant-analysis gas. It automatically opens or closes inlet ports in proportion to the rate of flow, and thus accurately maintains the ratio of gas to air.

◀ **2. Catalyst Brick**—the combustion chamber is filled with a specially treated brick that assures complete combustion and dissociation. Gives high-hydrogen content, low-residual hydrocarbon, and no oxygen.

◀ **3. Visual Flowmeters**—calibrated in cubic feet per hour to show the flow of gas and air. Mounted side by side, the air-gas ratio can be seen at a glance.

4. Straight-tube Surface Cooler—sizes 500 cfh and larger have a removable bundle of straight, easily cleaned, corrosion-resisting brass tubes.

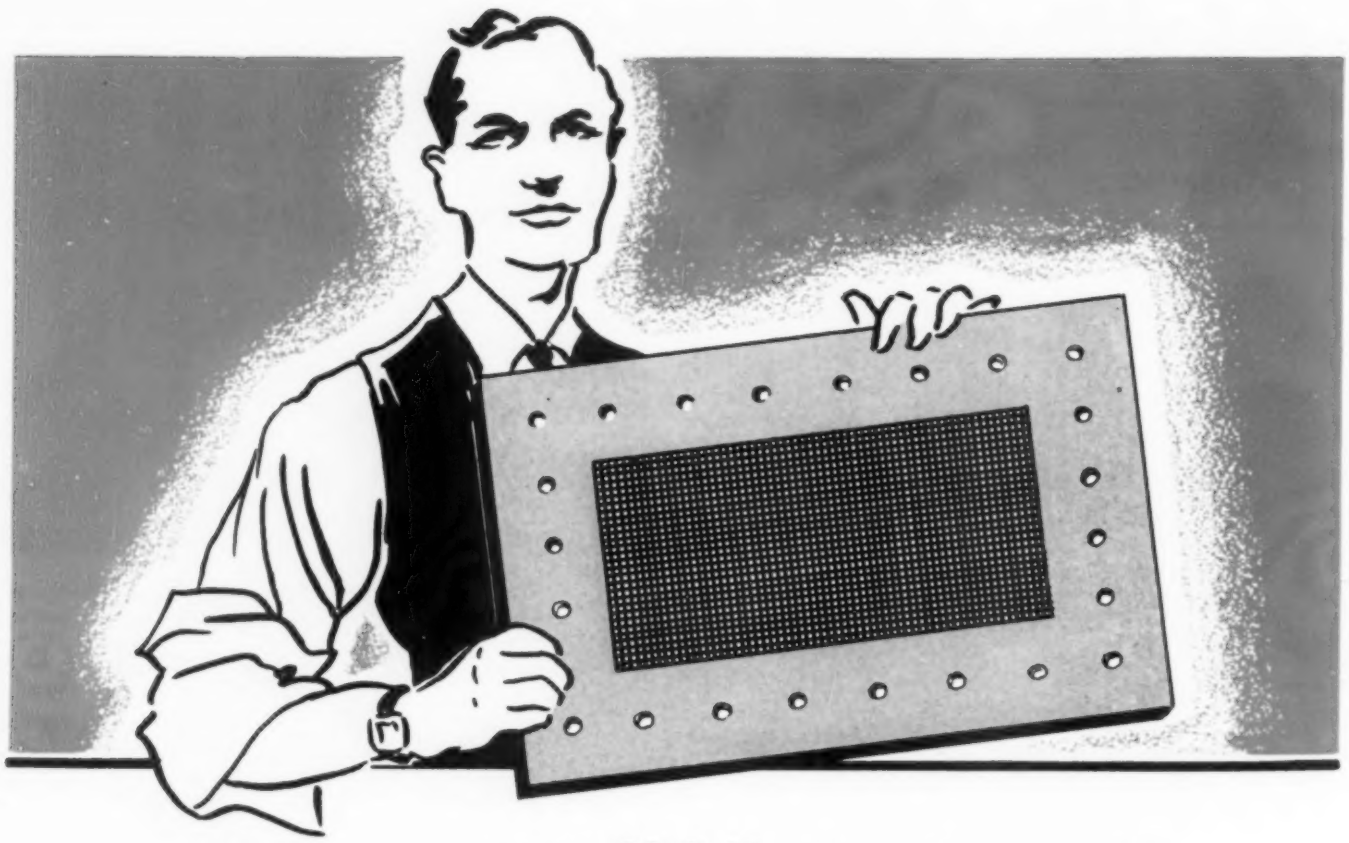
▼



GENERAL ELECTRIC PROVES FURNACE PERFORMANCE WITH LABORATORY TESTS

GENERAL ELECTRIC

160-89



How would YOU *harden it?*

This die was an actual job. We hardened it perfectly, despite the heavy outer shell, and the inner "honeycomb" section where the steel between the holes was almost *paper thin.*

For more than 20 years we have specialized on hardening Tools, Dies, and Molds. Every day (and night) you will find 46 skilled men here, treating hundreds of exacting jobs—different shapes and sizes—every known make and brand of steel. Seventy per cent of our volume is "fussy" work.

More than 2,000 manufacturers (many in distant States) entrust us with heat treating work. Lots of these firms have been customers of ours throughout all the years we've been in business!

What better guarantee of quality, fair price, and good service can anyone give?

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These heat treaters can solve those ultra-tough or unusual problems—or they can do your complete heat treating job, including carburizing, cyanide hardening, nitriding, tool, die, high speed steel and high carbon chrome steel hardening, etc.

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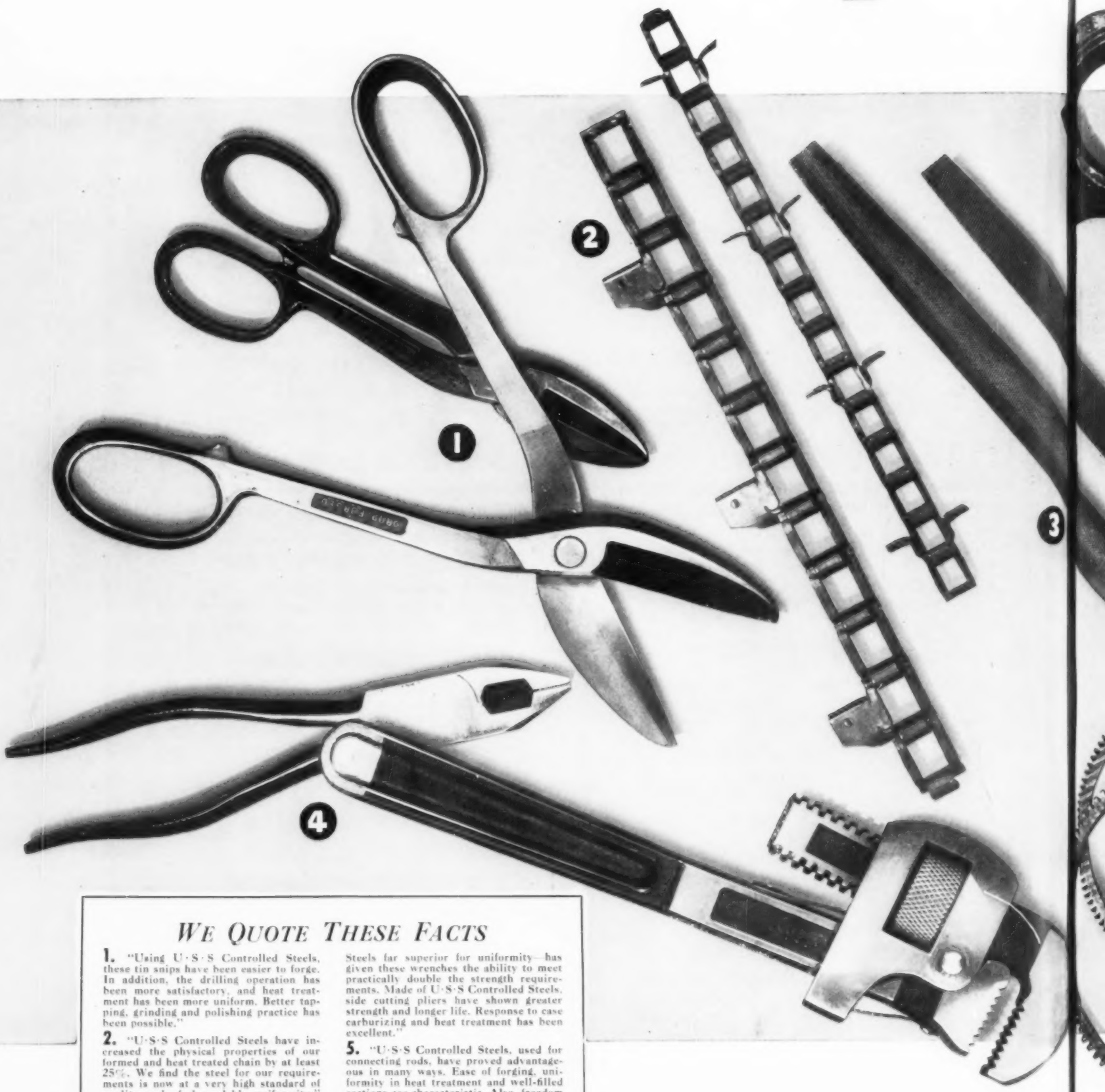
PHILADELPHIA
Lorenz & Son
1400 N. FRONT ST. • REGENT 7722 EAST 8255

PITTSBURGH
Pittsburgh Commercial Heat Treating Company
3708 LIBERTY AVE. • SCHENLEY 2188

WORCESTER
Greenman Steel Treating Company
284 GROVE STREET • 4-4024

The experienced commercial heat treating companies listed above are as near as your telephone . . . give them a call . . . they'll be glad to hop over and help with your heat treating problem.

Is there a Skeptic



We Quote These Facts

1. "Using U·S·S Controlled Steels, these tin snips have been easier to forge. In addition, the drilling operation has been more satisfactory, and heat treatment has been more uniform. Better tapping, grinding and polishing practice has been possible."

2. "U·S·S Controlled Steels have increased the physical properties of our formed and heat treated chain by at least 25%. We find the steel for our requirements is now at a very high standard of quality and of dependable uniformity."

3. "Since using U·S·S Controlled Steels there has been far more uniformity in all the processing operations, and many troubles have been eliminated. Better cutting of teeth, and hardening with less breakage and warpage are characteristics of the use of U·S·S Controlled Steels."

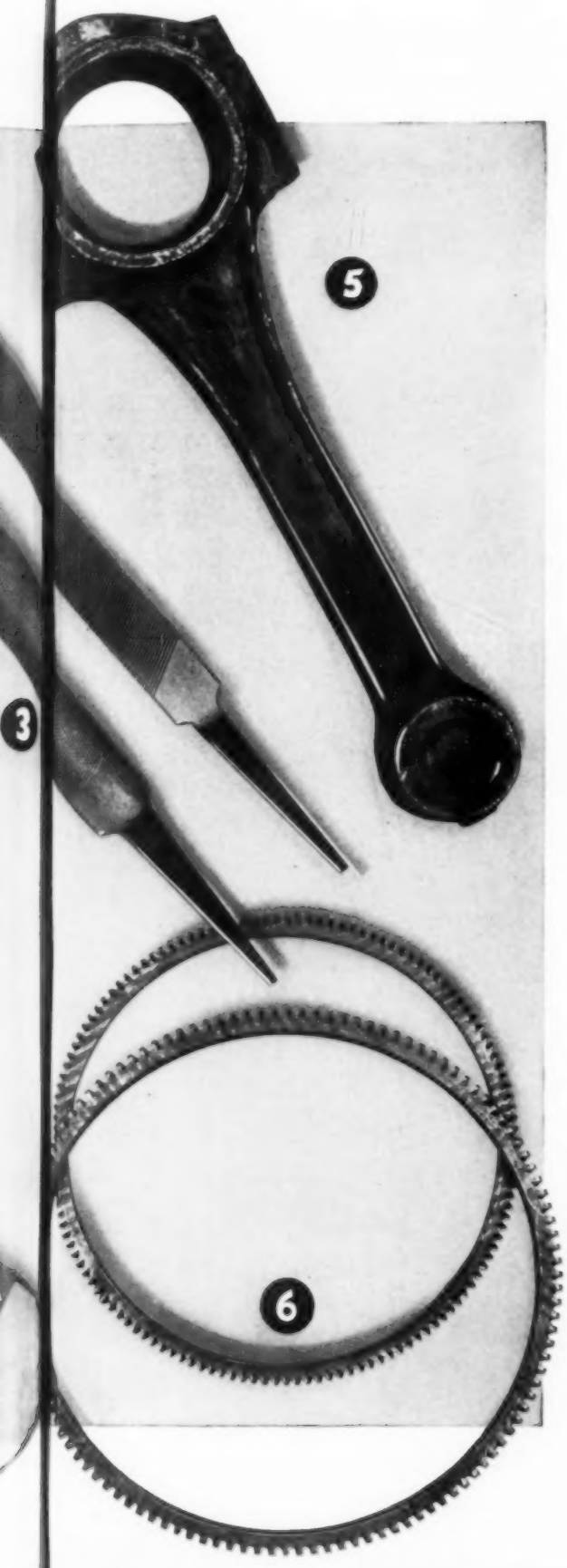
4. "In making Stillson wrenches performance has proved U·S·S Controlled Steels far superior for uniformity—has given these wrenches the ability to meet practically double the strength requirements. Made of U·S·S Controlled Steels, side cutting pliers have shown greater strength and longer life. Response to case carburizing and heat treatment has been excellent."

5. "U·S·S Controlled Steels, used for connecting rods, have proved advantageous in many ways. Ease of forging, uniformity in heat treatment and well-filled sections are characteristic. Also, freedom from trimmer cracks and quench cracks was noticeable, as well as marked toughness after heat treatment."

6. "With U·S·S Controlled Steels reruns on ring gears have been considerably reduced, the majority now being rerun for size only. Satisfactory performance has been noted with both fine and coarse grain steel, grade selected according to definite requirements."

U N I T E D

e in the House ?



WHEN we first announced Controlled Steels the Doubting Thomases had a field day. When we said that we could produce carbon steels in which *all* quality factors could be predetermined, in which variables could be scientifically eliminated, they were definitely from Missouri.

Now, only a few years later, many of them are among the largest users of U·S·S Controlled Steels. The drastic savings made in plants all over the country, due to better machining—reduced heat-treatment costs—easier forging and forming — and more consistent and uniform production generally have proved the case for U·S·S Controlled Steels.

Today in shops whose combined cost reductions run into hundreds of thousands of dollars yearly, they swear by these superior carbon steels.

In U·S·S Controlled Steels, control goes further than the mere close adherence to chemical specifications. It has to do with control of other vitally important properties—forging and machining qualities, response to heat-treatment, ductility, etc.—which so largely determine whether production in the steel user's plant will be wasteful or economical.

In U·S·S Controlled Steels we have proved it quite possible to furnish not only fine grain or coarse grain steel as required, but to maintain uniformity in shipment after shipment. Thus tool set-ups, heat-treating and forging procedures, once established for the steel, require minimum change. Reduced costs and better results follow as a matter of course.

Why not invite one of our metallurgists to look over your production line? If Controlled Steels will save you money he will show you how and where to use them to best advantage. It costs nothing to have him call.

Controlled Steels

USS

CARNEGIE-ILLINOIS STEEL CORPORATION

Pittsburgh and Chicago

Columbia Steel Company, San Francisco, *Pacific Coast Distributors*
United States Steel Products Company, New York, *Export Distributors*

STATES STEEL

Electric balancing sensitivity

Another feature of **BRISTOL'S WIDE-STRIP PYROMETER** *contributing to fine performance*

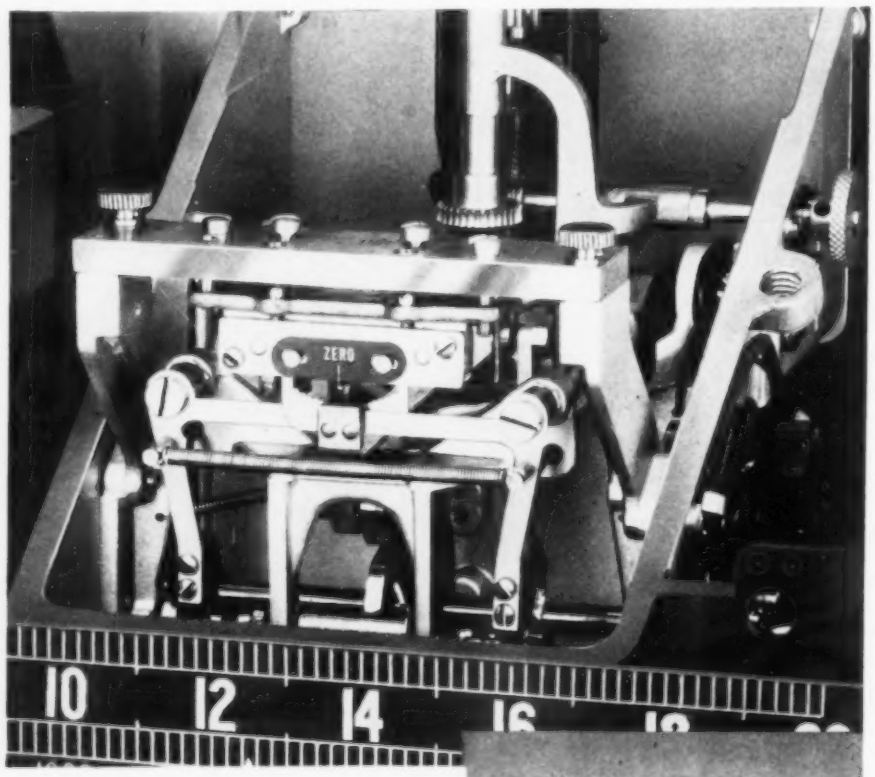
In responsiveness, too, this modern Bristol's Wide Strip Pyrometer will amaze you with its impressive performance. The instant the temperature changes, the galvanometer feels the change. Instantly the galvanometer pointer responds, even to slight temperature fluctuations so minute that the corresponding pointer deflection cannot be detected by the naked eye.

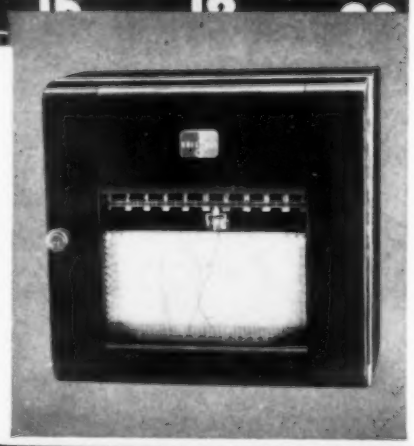
Then, because for such small galvanometer deflections the chopper arms have a contour that is smooth and continuous, corrective action is immediate. It is of *just the right amount* to make possible precisely *accurate control.*

The mechanical backlash in the chopper arms is completely taken up on each periodic movement. No clearance between chopper arms and pointer is required.

Feature after feature! All contributing to fine performance, and accurate temperature measurement and control. That is the story of Bristol's Wide Strip Pyrometer. Write for Catalog 1452H.

THE BRISTOL COMPANY
WATERBURY, CONNECTICUT
Branch Offices in Principal Cities





CRAFTSMANSHIP ***you can see at a glance!*** Reflecting throughout the simplicity, beauty and perfection that identify the genius of the master craftsman, this Bristol's Wide-Strip Pyrometer possesses many other interesting features that you will want to know about. The following will be discussed in subsequent advertisements: (a) Circuit automatically standardized, (b) Electric balancing, (c) No lost motion, (d) Visible operating mechanism, (e) Extra wide 12¼ inch chart, (f) Duplex slide wire accuracy, (g) Large easy to read scale, (h) Automatic cold junction compensator.

BRISTOL'S
TRADE MARK REG. U. S. PAT. OFF.
Wide-strip Pyrometer

RECORDING ★ CONTROLLING ★ MULTIPLE RECORD MODELS

BRIGHT HARDENING LIKE THIS ISN'T MAGIC..

IT'S *Hydryzing!*

If you harden springs, stampings, or other small parts here's a really simple way to improve your product and save plenty of money doing it.

TAKE ADVANTAGE OF THIS OFFER

• Send us a batch of your parts today. We'll Hydryze and return them to you promptly. There is no obligation, and you can actually see for yourself what Hydryzing will do for your own products.

Have you often wondered how you could harden your springs, stampings, and other small parts without scale or discoloration? You can, and not only harden them without scale or discoloration, but harden them absolutely bright so that their original shiny surfaces are preserved intact.

Thus, you no longer need remove scale from hardened parts by means of pickling, sandblasting or other cleaning operations. Hydryzed parts look better because of their smooth, shiny surfaces, and take a smoother plating job because there are no pits due to scaling or subsequent cleaning operations. We'll be glad to Hydryze a batch of your parts to demonstrate the many savings possibilities of Hydryzing.

LINDBERG ENGINEERING CO.

222 No. Laflin St. Chicago, Ill.

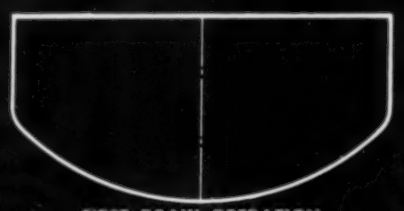
LINDBERG FURNACES

HYDRYZING FOR HARDENING • CYCLONE FOR TEMPERING

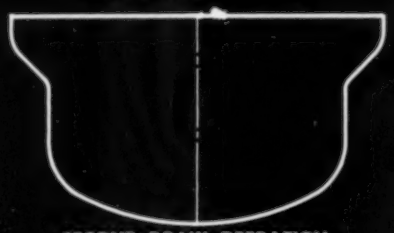
Aluminum

• HAS •

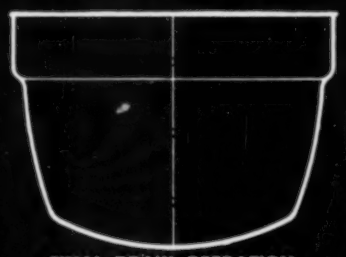
SUPERIOR WORKABILITY



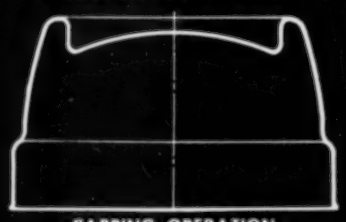
FIRST DRAW OPERATION



SECOND DRAW OPERATION



FINAL DRAW OPERATION



CAPPING OPERATION

Aluminum is formed like any other metal. Standard equipment and the usual skilled labor are employed. Its excellent working properties, however, contribute greatly to the economic production of finer products.

Metal workers will be interested in the steps by which Alcoa Aluminum beer barrels are formed in regular production-line manufacture. Three progressive draws and a fourth capping operation completely shape a beer barrel half, ready for assembly by the welder.

Dies and depth of draft, of course, take into account the individual characteristics of the alloy being used. That's part of the "know-how" gained by Alcoa engineers in years of dealing with the fabrication of Alcoa Aluminum Alloys. This information is available to you. ALUMINUM COMPANY OF AMERICA, 2101 Gulf Bldg., Pittsburgh, Pa.

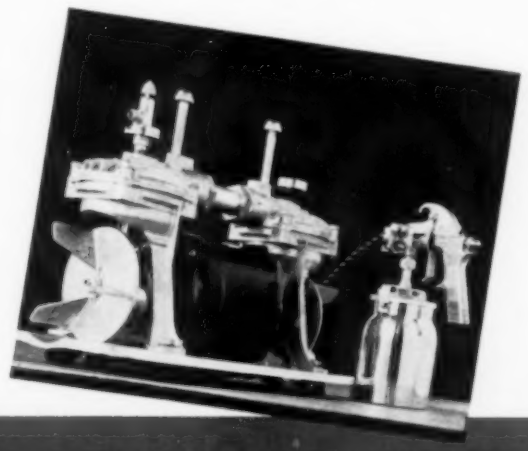
ALCOA ALUMINUM

Aluminum BECAUSE OF ITS LIGHT WEIGHT AND DURABILITY

Binks Manufacturing Company of Chicago wanted to produce an air compressor for paint spray work, which could be carried about easily. It had to be sturdy enough to withstand hard usage. They say, "Naturally, we turned to Aluminum."

The resulting unit, shown below without its streamlined cover, weighs only 44 pounds. It is carried like a small suitcase. The Alcoa Aluminum die castings pictured here are important contributors to its light weight and compact sturdiness.

The die casting process gives an accuracy of dimensions and a fineness of surface and details which greatly reduce fabricating time and costs. Have you investigated the use of Alcoa Aluminum die castings as a means of improving your product and cutting costs? Our engineers will gladly help you make such a study. ALUMINUM COMPANY OF AMERICA, 2101 Gulf Building, Pittsburgh, Pennsylvania.



ALCOA ALUMINUM

FAST HEATING BUT NO OVERSHOOTING IN MICROMAX CONTROL

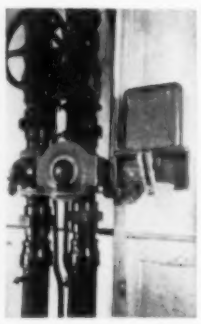
Taking charge once every five minutes of a fresh furnace-load of light metal stampings, the Micromax Electric Control equipment shown below relieves operators of all supervision of the heating and leaves them nothing to do but load the furnace cars and slide them into the furnace when the Micromax-actuated lamp comes on.

Changes in weight of load, changes in fuel pressure, and all other variables are automatically compensated for and cannot affect the heating.

Control is directed and temperature recorded by Micromax-equipped panel.

Parts being annealed are destined for subsequent stamping and deep-drawing operations, and the anneal is so uniform that rejects due to heat-treatment are almost unknown.

Any other fuel-fired furnace — batch, car-bottom, or continuous belt-fed—could use this identical Micromax Control, without removal or addition of a single part. And temperature would be held as closely as furnace design and construction permit. Any plant can standardize on Micromax Control, for the protection of product quality and reduction of manufacturing costs. Catalog N-00B, "Micromax Electric Control", explains the Control, and our engineers are always ready to help you apply it.

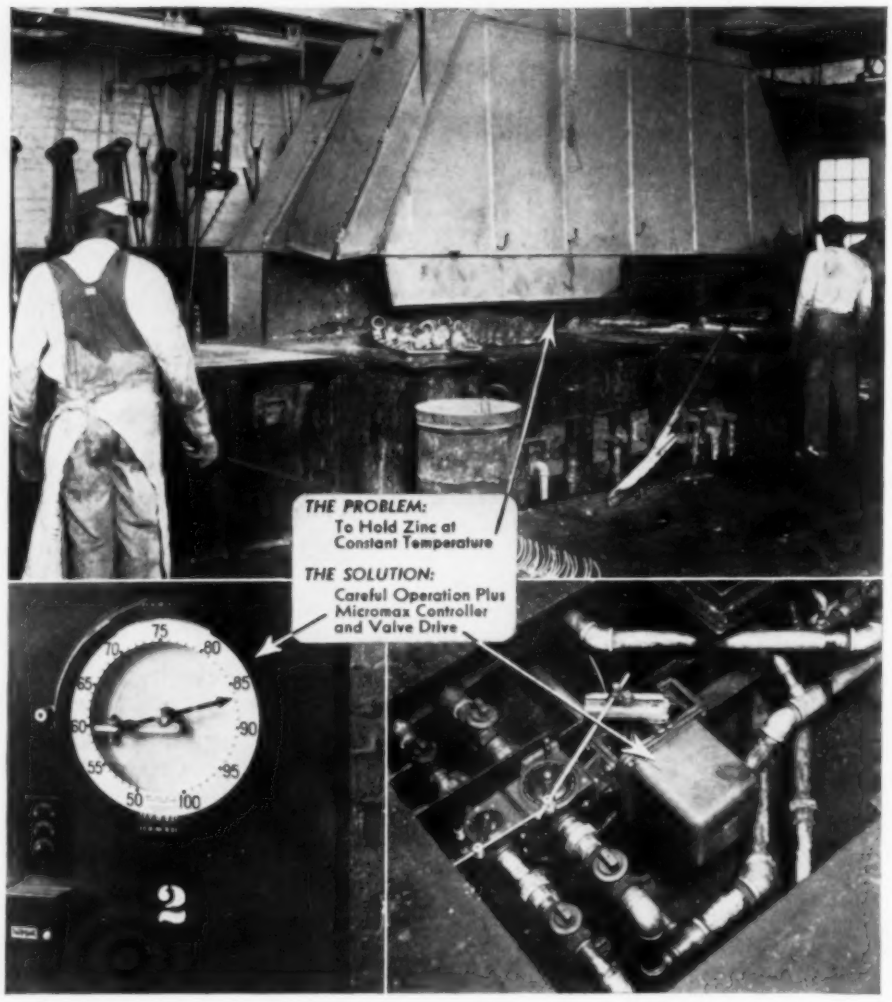


Fuel and air valve to furnace, and Micromax Electric Control valve-drive.

New Catalog of Lab Instruments

All L&N laboratory and test potentiometers, bridges and accessories, as well as all our other high-precision laboratory instruments, are briefly described and priced in our condensed Catalog E, just published for the first time. A copy will be sent on request.

Jrl Ad EN-0600A(1)


THE PROBLEM:
To Hold Zinc at Constant Temperature
THE SOLUTION:
Careful Operation Plus Micromax Controller and Valve Drive

It's Easier to Put Zinc on Steel When Micromax Controls Its Temperature

Because correctness of temperature is now a "must" for first-rate galvanizing, a pipe-fittings plant recently put the temperature-control problem squarely up to Micromax. And Micromax is making the work easier, in at least 3 ways:

1. Workmen and foremen can read temperature, at any time and from any distance within the room. Even men who can't sign their names can tell temperature by the clock-like dial. Everyone is completely informed.

2. Control is extremely accurate because the micro-responsiveness of the Micromax instrument is carried through directly to gas and air valves. Never moving widely, these valves are nevertheless almost constantly in slight motion—just as though the foreman himself were operating them to head off temperature swings and keep them headed off.

3. Little service attention—ridiculously little—is required, and neither repair parts nor adjustments have been needed.

Any furnace, burning any fuel, can have these same advantages from an identical Micromax Controller. You can standardize on Micromax.

Write For Catalog N-33A, "Micromax Pyrometers"

LEEDS & NORTHRUP COMPANY, 4927 STENTON AVE., PHILA., PA.

LEEDS & NORTHRUP

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

LATROBE

Latrobe ELECTRIC STEEL COMPANY

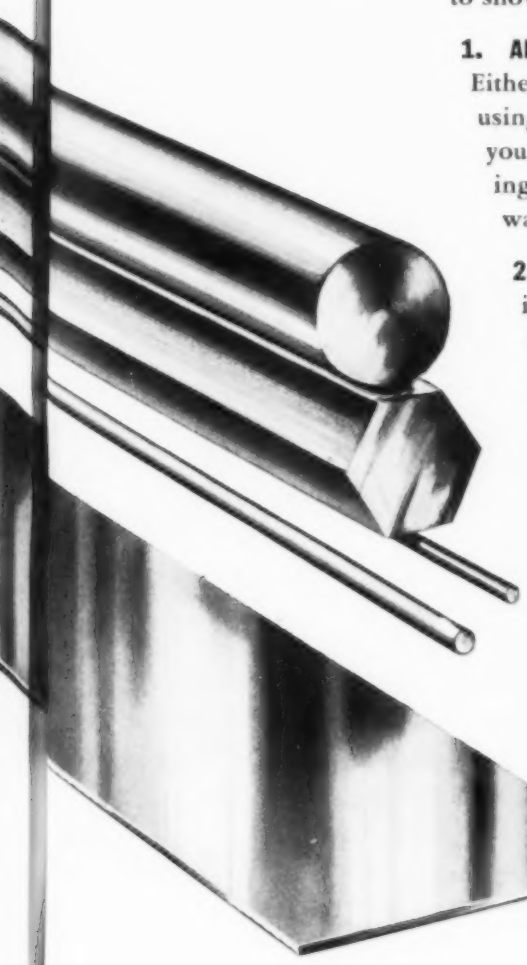
MAIN OFFICES *and* PLANT •• LATROBE • PENNSYLVANIA

DESIGN
THE CARPENTER STEEL COMPANY
READING, PENNA.
DRAMATIZE YOUR PRODUCT
THE EASY, ECONOMICAL WAY
Do it with Carpenter Stainless Steel. Of 363 manufacturers recently questioned by the best known trade publication in the product design field, 198 stated that they were using Stainless Steel more extensively than any other material in making product improvements. If you, too, are planning product pep-ups, let this new Carpenter pamphlet show you how to save money doing it. It's free. Just use the coupon on the opposite page.
WHO MUST
QUESTION—
E DESIGN
APPEAL
ODUCT?"

THE CARPENTER STEEL COMPANY

Carpenter STAINLESS

5 NEW WAYS TO MAKE SHOP SAVINGS WITH STAINLESS STEEL...



Whether you are in Production, Purchasing, or Design, this new Carpenter DESIGN BOOKLET will help you cut fabrication and material costs. Developed from shop practice, it gives you in familiar, easy-to-understand shop terms, important new hints for cutting Stainless costs. Here, for example, are 5 practical suggestions drawn from the booklet to show you what you may expect—

1. ARE YOU BUYING TOO MUCH OR TOO LITTLE CORROSION RESISTANCE? Either is unprofitable and unnecessary. If you are not sure that you are using the one grade of Stainless that gives you the best profit balance, you may be running production costs too high on the one hand, or losing customers unnecessarily on the other. Do you know the quick, easy way to find out?

2. CHECK INTRICATE SHAPES FOR POSSIBLE SAVINGS! You can frequently improve parts having recesses, sharp re-entrant angles, holes and sharp corners—and save money besides. What method will eliminate plating costs on such parts and decrease rejects due to peeling and dangerously thin deposits, *without increasing forming costs?*

3. SHEATHING MIGHT SAVE YOU 50% OR MORE! Manufacturers of rolled and stamped moldings are making such savings every day. They use a light gauge Carpenter Stainless strip over a base of heavy gauge material. Where and when is this type of saving practical for your product?

4. ARE PROCESS ANNEALING COSTS TOO HIGH? There are several ingenious methods for reducing them besides using Carpenter's very ductile grades of Stainless. What other procedures can you follow to gain those additional reductions?

5. COMPARE THE COST OF PURCHASING STANDARD PARTS FROM SPECIALISTS! This excellent source of extra manufacturing profits is often neglected. Yet nearly every standard metal product is now made in Carpenter Stainless by large scale producers. How can you get the additional information you need to turn this fact into real savings?

The answers to all these practical manufacturing questions and many more like them can be found in Carpenter's new Stainless Steel DESIGN BOOKLET. Without obligation, get for yourself the help it offers. Use the coupon below. We will send you your free copy at once. It will give you the latest hints on how to improve your product and make shop savings through better Stainless design. Send for it today.

FREE
IN U. S. A.

Y EADING, PA.

STEELS

THE CARPENTER STEEL COMPANY
133 W. BERN ST., READING, PA.

Yes, I want to know the latest methods for making economical improvements in my product with Stainless Steel. Without obligation, please send me your new Stainless DESIGN BOOKLET.

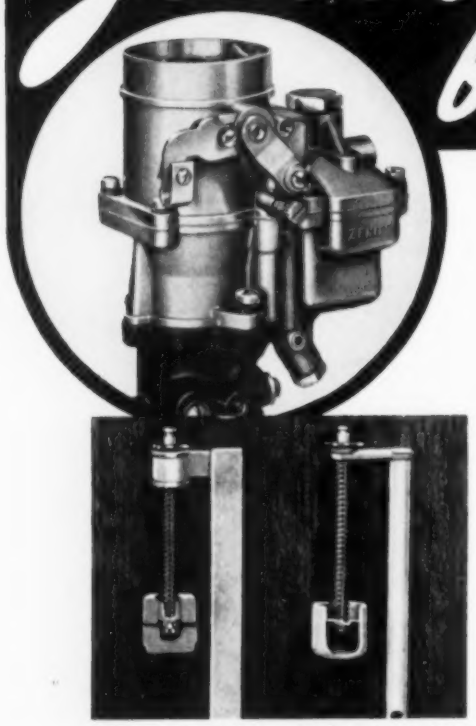
NAME_____ TITLE_____

FIRM_____
(Firm Name Must be Given)

ADDRESS_____

CITY_____ STATE_____

Zenith SAVES 24% by BRAZING



This shows the "before" and "after" design of the accelerating pump piston. The new design is at the right.

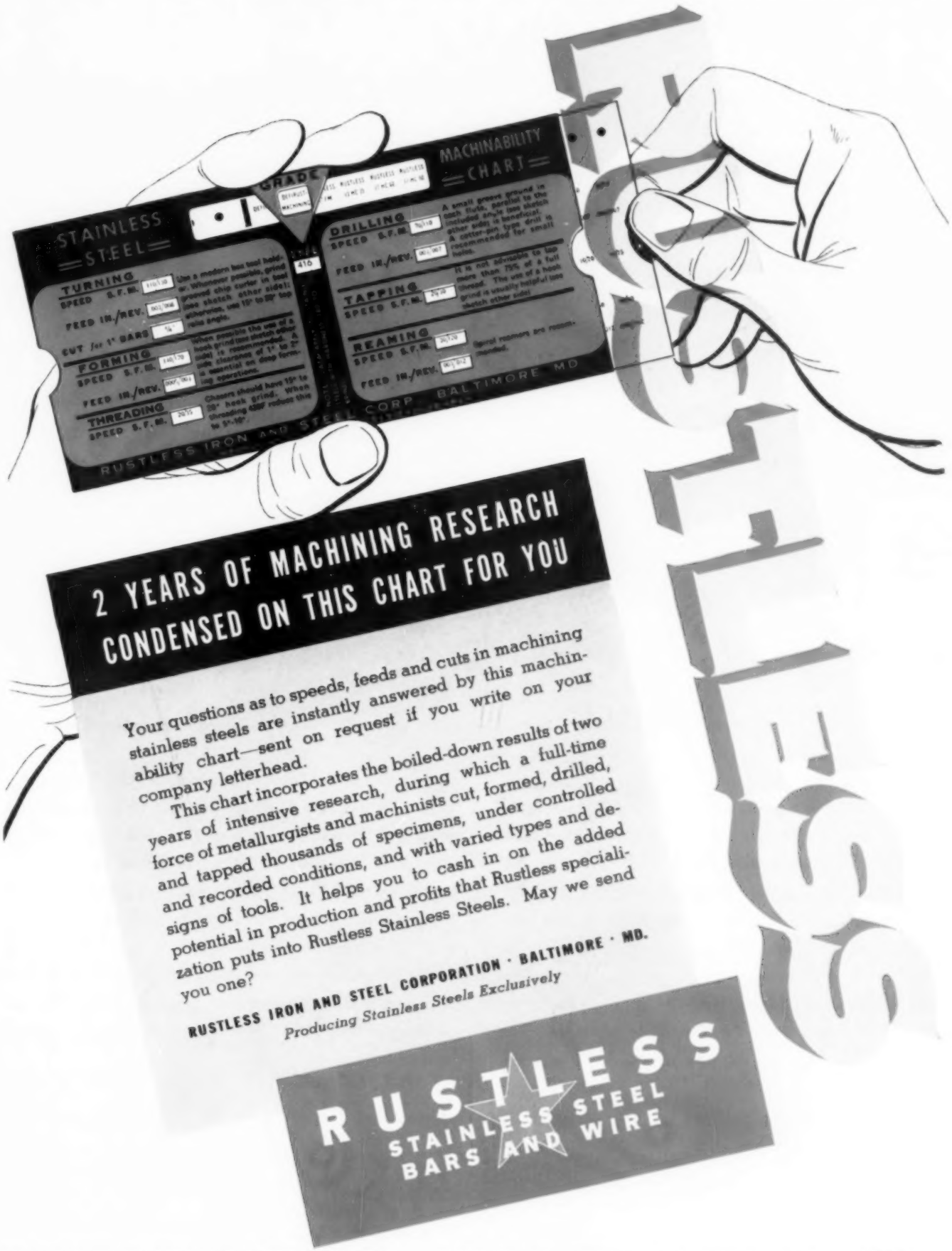
The accelerating pump piston of the Zenith Carburetor used to be an assembly of machined parts. It is now made of metal stampings, made possible by copper brazing in the Hoskins Brazing Furnace shown above. As a result, Zenith cut their production cost on this item by 24%. By doing the same thing to the throttle lever, its cost fell 27%. This shows the soundness of the investment made by Zenith in their Hoskins Brazing Furnace. If your product permits of a similar change in design, or if you braze tungsten-carbide to tool steel, complete information about this furnace will be of value to you. The facts are presented in Catalog-57. Write for a copy. . . . Hoskins Manufacturing Co., Detroit, Michigan.

HOSKINS PRODUCTS

ELECTRIC HEAT TREATING FURNACES • • HEATING ELEMENT ALLOYS • • THERMOCOUPLE AND LEAD WIRE • • PYROMETERS • • WELDING WIRE • • HEAT RESISTANT CASTINGS • • ENAMELING FIXTURES • • SPARK PLUG ELECTRODE WIRE • • SPECIAL ALLOYS OF NICKEL • • PROTECTION TUBES

Chromel HEATING ELEMENT WIRE

PRODUCED BY AN ORGANIZATION MAKING STAINLESS STEELS EXCLUSIVELY



2 YEARS OF MACHINING RESEARCH CONDENSED ON THIS CHART FOR YOU

Your questions as to speeds, feeds and cuts in machining stainless steels are instantly answered by this machinability chart—sent on request if you write on your company letterhead.

This chart incorporates the boiled-down results of two years of intensive research, during which a full-time force of metallurgists and machinists cut, formed, drilled, and tapped thousands of specimens, under controlled and recorded conditions, and with varied types and designs of tools. It helps you to cash in on the added potential in production and profits that Rustless specialization puts into Rustless Stainless Steels. May we send you one?

RUSTLESS IRON AND STEEL CORPORATION · BALTIMORE · MD.

Producing Stainless Steels Exclusively

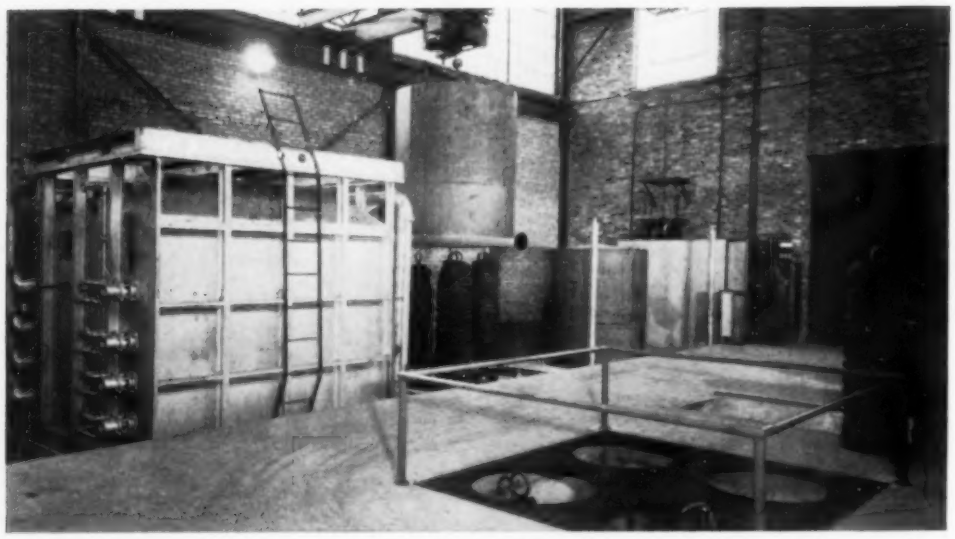
RUSTLESS
STAINLESS STEEL
BARS AND WIRE

SALES OFFICES: CHICAGO—4201 IRVING PARK ROAD · **CLEVELAND**—731 SOCIETY FOR SAVINGS BUILDING · **DETROIT**—4-137 GENERAL MOTORS BUILDING · **PHILADELPHIA**—1263 COMMERCIAL TRUST BUILDING · **DISTRIBUTORS IN PRINCIPAL CITIES**

Speed up production,

cut annealing cost . . . with

Modern GAS Equipment



Gas-fired radiant tube annealing furnace in plant of Wilson Steel and Wire Co., Chicago, makers of tinned, galvanized, annealed and bright wire, all sizes of nails, tacks and rivets, as well as bale ties and straight and cut wire. Photograph courtesy Surface Combustion Corporation.

IN the plant of the Wilson Steel & Wire Co., Chicago, a new Gas-fired radiant tube annealing furnace turns out 14,000 pounds of wire per heat and averages 40,000 pounds per day. This output is 2½ times that of the two previously used furnaces fired with another fuel and is typical of the increased speed of production with modern Gas equipment.

Only one operator is required to handle the new furnace, compared with a fireman and two material handling men for the older furnaces. The tare heating weight of the new unit is 4,300 pounds, compared with 24,000 pounds of the old units.

Here is but one more special heat-treating problem smoothed by Gas and up-to-date equipment. Perhaps your plant has its own heat treating problem that may be solved with Gas. If you want to speed up your production, cut your operating costs, and improve the quality of your finished product, it will pay you to investigate Gas—and modern Gas Equipment. Your Gas company will be glad to give you full information on the most advanced Gas Equipment for your heat treating operations.

AMERICAN GAS ASSOCIATION

INDUSTRIAL GAS SECTION

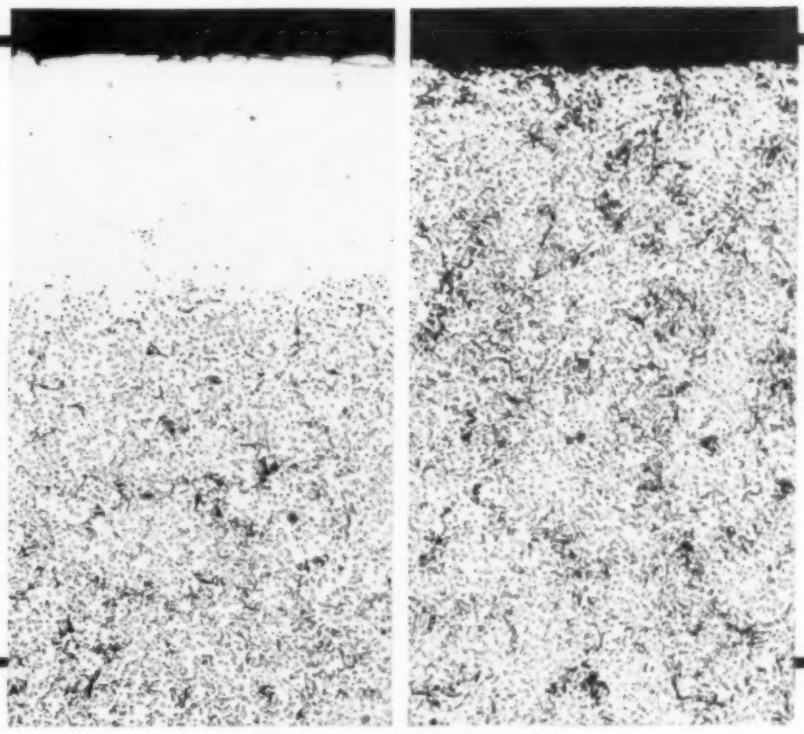
420 LEXINGTON AVENUE, NEW YORK CITY

S·A·E 52100
BALL BEARING STEEL

SCALE-FREE HARDENED WITH *No* DECARBURIZATION

Ordinary
Scale-Free Hardening

Micro-section, on left, reveals that decarburization occurs to a depth of approximately .005 inch, when S.A.E. 52,100 Ball Bearing Steel is treated in an ordinary scale-free gas atmosphere at 1500° F. for one hour.



Magnification 500X — Unretouched

Westinghouse
Scale-Free Hardening

Micro-section, on right, proves conclusively that no decarburization occurs when S.A.E. 52,100 Ball Bearing Steel is heat treated in the new Westinghouse ENDOGAS atmosphere at 1500° F. for one hour.

S.A.E. 52,100 is but one of many hard-to-handle steels which the recently perfected Westinghouse ENDOGAS atmosphere enables you to harden or anneal with complete freedom from decarburization. In fact, this new process permits scale-free hardening of all S.A.E. steels without "decarb."

Good news, too, is the fact that the new Westinghouse ENDOGAS atmosphere is inexpensively created from ordinary natural or manufactured city gas . . . without the use of costly driers or CO_2 removal equipment. It's extremely low in CO_2 content and high in CO.

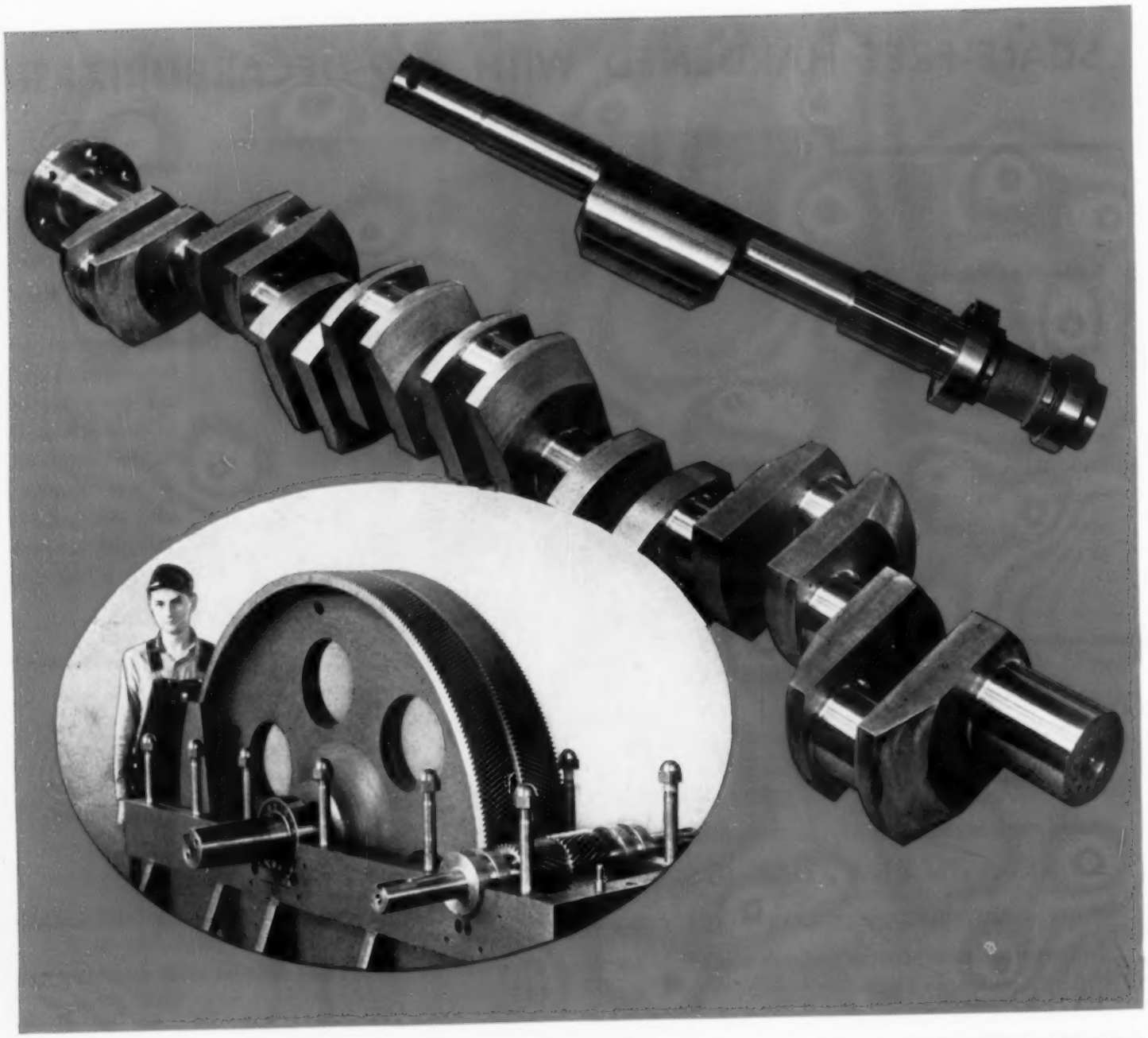
WRITE TODAY FOR COMPLETE INFORMATION

Complete technical data is now available on how to apply this low-cost method of hardening and annealing under production conditions. Let it be your guide to getting the jump on competition. Write today to Dept. 7-N, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

J-10150

Westinghouse
Complete Heat Treating Equipment

The Increased Efficiency



REPUBLIC

Metal Progress: Page 718

# of Large Alloy Sections

Proves Economic

● When sections are large — when hardness must be carried deep into the steel — alloy steels are necessary and the cost very low in proportion to the benefits obtained.

Large sections, where the use of alloy additions of nickel, chromium, vanadium, manganese and molybdenum is then economically justified, include shafting, crankshafts for diesel engines and stamping machinery, steam hammer piston rods, large gears, axles and heavy connecting rods.

In such parts, with carbon kept constant, the depth-hardening quality increases as the alloy content is increased. However, expert knowledge is required to work out the proper combination of alloys for any specific-purpose steel — and it is then that the experience of Republic, the world's largest producer of alloy steels, will, like the steel itself, prove economic.

REPUBLIC STEEL CORPORATION
GENERAL OFFICES: CLEVELAND, OHIO
ALLOY STEEL DIVISION: MASSILLON, OHIO

BERGER MANUFACTURING DIVISION • NILES STEEL PRODUCTS DIVISION • STEEL AND TUBES DIVISION
TRUSCON STEEL COMPANY • UNION DRAWN STEEL DIVISION

REPUBLIC STEEL

WORLD'S LARGEST PRODUCER OF

Alloy Steels

When writing Republic Steel Corp. for further information, please address Dept. M.P.

"ROCKWELL"
HARDNESS TESTER

Reality

One on your bench helps you a lot.

One of thousands of "ROCKWELL" Hardness Testers now in daily use is shown in the illustration above. It is typical of these machines that have enabled the departments or plants using them to do the following:

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2. Discuss orally or in writing the matter of hardness of material in terms everyone will understand.

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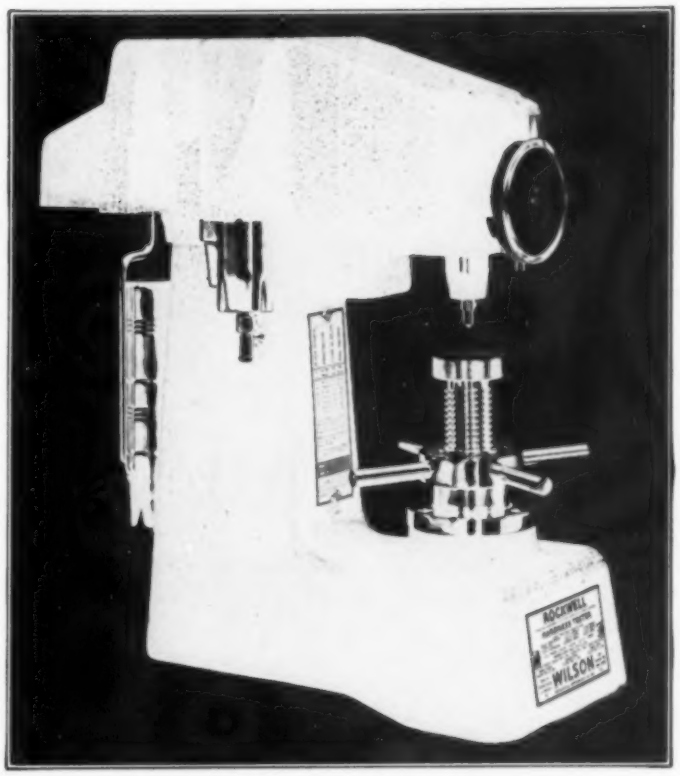

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3. Make use of published "Rockwell" hardness data or receive and use information on hardness from steel companies or from others heat treating steel.

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Metal Progress

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December, 1939; Volume 36, Number 6

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Industrial Gears

for large transmissions

While much has been published about automotive transmission gears, little or nothing has appeared about the manufacture of large industrial gears, especially high speed gears for transmitting large amounts of power, such as rolling mill drives or reduction units between steam turbines and propeller shafts. This first article notes the requirements for such gears and the relative merits of plain and alloy steels in both castings and forgings. A subsequent article will discuss the heat treatment of these large masses of metal.

By Edward J. Wellauer*

EACH YEAR the materials in industrial power transmitting gear trains are relied upon to carry millions of horsepower in a trouble-free manner. The metallurgical aspects of these large gear drives have been developed by much research work and service experimentation. In contrast to automotive gears, industrial gear drives have not been widely discussed in the technical press, and it must be emphasized at the outset that the design, load, service, and heat treating practices are entirely different in these two fields.

The automotive drive is a relatively elastic system and consequently capable of distributing safely such shocks as it receives; the expected life is very short — on the order of 3000 hr. The great production volume allows extensive preliminary research to determine the exact mechanical design and proper tooth contact to provide the optimum service.

In contrast, the average industrial drive might have to operate 25,000 to 50,000 hr. continuously. The loading is usually of an undetermined or even indeterminate nature and can include undesirable shock or vibration. These variables, in conjunction with the prohibitive cost of a large unit, do not allow much full-sized experimentation, yet these big gears *must* not fail. Under these circumstances the loadings are usually limited by the allowable deflection of the tooth; furthermore, both contact and bending stresses must be below the endurance limit of the material.

Spur, helical, bevel and worm gears are used to transmit power in many different types of industrial speed-reduction units. The loads vary from fractional horsepowers to more than 30,000 hp. per unit. The speeds may exceed 8000 r.p.m. with pitch line velocities as high as 18,000 ft. per min. Lubrication might vary from the most refined automatic pressure oiling system to haphazard swabs of a grease brush.

Under these service conditions, industrial gears can fail by breaking of a tooth by bending, by fatigue or impact (in rare cases), or by loss of metal from the working face. Surface or profile failure is caused by pitting, spalling, scuffing, rolling, plastic deformation, or gradual wear. Profile failure has occurred, in a practical sense, when the load can no longer be transferred in a satisfactory manner, either in terms of excessive noise, inadequate smoothness of operation, or too much heating.

Pitting is the major cause of profile failure. Pitting is identified by the formation of concave pits ranging from very large ones common to heavily loaded, coarse pitch commercial gears

*Research Engineer, The Falk Corporation, Milwaukee, Wis.

to very numerous small pits, fully or partially distributed over the profile of fine pitch gears. These pits actually impair tooth action and are not to be confused with the non-progressive initial pitting which sometimes occurs during running-in. Stresses causing such pits are due to subsurface shear stresses which can be computed by methods suggested in 1881 by Hertz who solved, mathematically, the stresses to be expected when two elastic solids are in contact under load. Necessary design data to resist pitting have been presented by W. P. Schmitter in *Machine Design* for June and July 1934.

Spalling is very similar to pitting except that the dislodged particles are much larger and extend over the entire tooth profile, and is probably caused by higher overloads.

Scuffing is caused by a combination of pressure and velocity resulting in a drawing action at the extremities of tooth contact.

Rolling is similar to scuffing except that a failure of the lubricant has allowed a complete seizure of the mating profiles. The failure is identified by parallel scratches and concave grooves along the teeth perpendicular to the axis of rotation. It is illustrated on page 727.

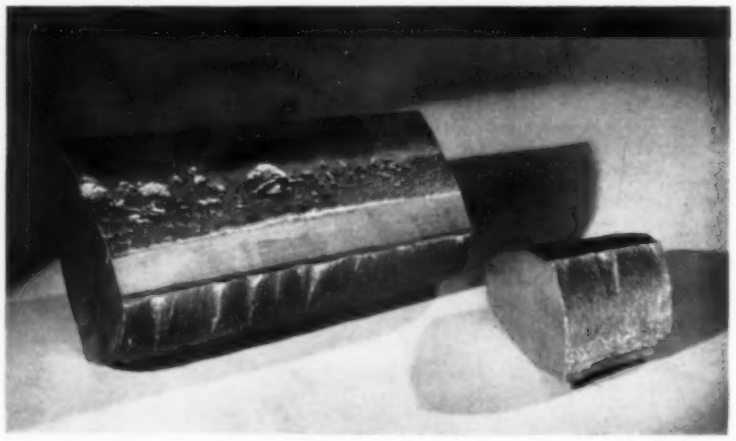
Plastic Deformation. With excessive contact stresses, the profile can be flattened or concaved; it is prevented by limiting the stresses to values below the shear yield.

Wear. Actual wear is usually caused by abrasive particles getting into the gear box or fouling the lubricant, or chemical attack by lubricants or external agencies.

Failure by breakage and pitting can be partially controlled by increasing the strength (especially the combination of fatigue strength and wear resisting hardness) and therefore by the selection and heat treatment of materials. The other types of failure are principally due to errors in design or manufacturing, or to operating factors; higher physicals can aid in minimizing these destructive effects but the only suitable solution lies in correcting the fundamental causes. The gear metallurgist's efforts are therefore based on the assumption that the gear train has received adequate design, which includes suitable provisions for satisfactory lubrication and mounting. Based upon the computed operating stresses, he then decides upon the material and its heat treatment to produce the desired physical properties. As a matter of fact, it is impossible to specify definitely the physical properties to resist breakage because we cannot now accurately determine the developed stresses. This is particularly true of calculations for bending strength of gear teeth, since there have been very little correlated test data obtained from modern commercial gear sets which are pertinent to the question. All that the designer can do is to adopt one of the recently proposed formulas and accumulate experience to provide a fair relation between the type of gear, service conditions, calculated stresses, and physical tests.

The table opposite gives typical tests from medium and larger sized commercial gears (which are usually cut after heat treatment).

Uncertainties concerning bending stresses in gear teeth are not extremely serious because experience has proven that profile durability is of more importance. The heat treatment required to secure proper durability will usually provide from three to over six times the strength necessary. The tooth shown in the first illustration is a good example, since the profile failed considerably before the tooth broke due to a fatigue crack initiated by machine marks. (The condition shown at the bottom of this tooth is typical of large pitch spur bevels produced on a certain make of machine.)



Coarse Pitched Gear Tooth That Had Failed by Severe Pitting on Profile Before a Fatigue Crack at Base, Initiated by the Machine Tool Marks, Caused It to Let Go. Satisfactory replacement had ample radius at root of tooth, a smooth, harder surface, and a proper lubrication system

Experience and extensive testing have indicated that gear profile durability is a function of the Brinell hardness. The term "gear profile durability" rather than "wear resistance" is used

Typical Steels Used in Large Industrial Gear Sets

	Forgings		Castings	
	Cr-Ni-Mo Steel		Mn-Mo Steel	Carbon Steel
	Normalized and Tempered	Liquid Quenched and Tempered	Double Normalized and Tempered	Annealed
Composition: Carbon %	0.35 to 0.45	0.30 to 0.40	0.40	0.30
Manganese	0.50 to 0.70	0.45 to 0.65	1.25	0.50 to 0.70
Molybdenum	0.25 to 0.35	0.25 to 0.35	0.20	
Chromium	0.65 to 0.95	0.65 to 0.95	....	
Nickel	1.25 to 2.00	1.25 to 2.00	....	
Tensile Properties:				
Yield point, psi.	85,000	105,000	56,000	42,000
Tensile strength, psi.	112,500	135,000	90,000	75,000
Elongation in 2 in.	23%	20%	24%	25%
Reduction of area	52%	55%	50%	40%
Brinell hardness	235 to 270	260 to 295	175 to 200	130 to 150
Test specimen	Mid-radius bar	Mid-radius bar	Attached coupon	Attached coupon

advisedly; its relationship to indentation hardness is rather well known for values between 180 and 400 Brinell. In the ordinary hardness ranges, the tensile strength and approximate endurance limit have a fairly uniform relation to the Brinell hardness, so it seems logical to believe that the Brinell or Rockwell test is a more accurate method of measuring (or specifying) the resistance of materials to contact stresses than the tensile test. This is in line with the experience of automotive engineers, who insist on a much higher degree of hardness ("file hard") for the working surfaces of transmission gears.

It has been found that the following combinations are satisfactory for cast steel gears for general purposes, medium to large size, which are cut after heat treatment:

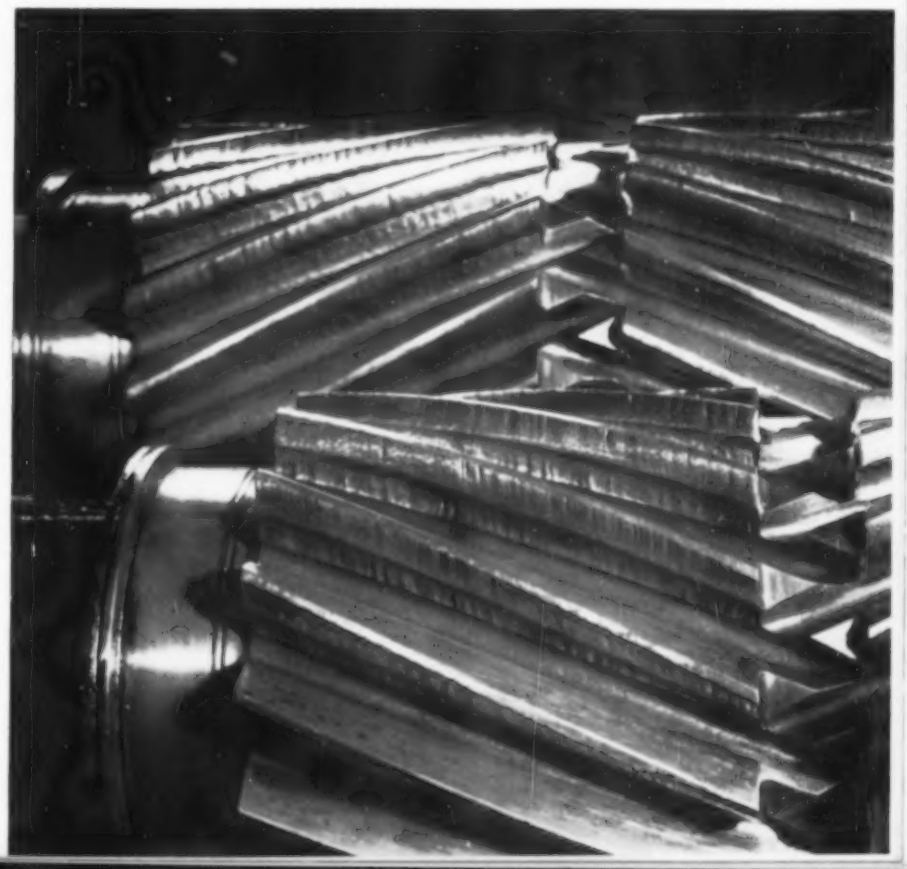
Brinell Hardness		Applications
Pinion	Gear	
235 to 270	140 to 180 (annealed)	General drives where loading does not require a heat treated gear, or where gear is too large to quench.
260 to 295	225 to 260	Locations where greater capacity is required when gear can be quenched and tempered.
330 to 360	285 to 330	For smaller gears using steels especially controlled and treated for machinability.

Higher hardness for small gears can be obtained by carburizing or heat treating after cutting (to be discussed in a later article).

Concurrently with a decision as to physical properties, the metallurgist must decide on the type of material, cast iron or steel (forging, rolled shape, casting), its chemical analysis and the required heat treatment.

Cast Iron. It is difficult to evaluate the position of cast iron because the recent developments in foundry technique, alloying and heat treating procedures have not been fully tested under actual service of large gear sets. A metallurgist cannot afford to order gears or any other high duty item by the mere term "cast iron" without stating the analysis, physicals, and

Double Herringbone Pinions That Failed by "Rolling". The concave scratches and grooves perpendicular to the root of the teeth are caused by deficient lubrication and seizure of mating profiles. The lines from end to end of tooth, parallel to the axis of the gear shaft, represent a change in the direction of sliding, at the pitch line



metallographic structure desired. Cast iron is not as versatile as steel in regard to the properties available by various heat treatments and analyses. Furthermore, its quality is dependent to a very large degree upon founding practice. Inherently, cast iron is relatively weak and brittle when compared with cast or forged steels.

Arguments in favor of cast iron have been based on its low modulus of elasticity which should allow the development of a greater contact area, tooth to tooth, and hence improve lubrication and other factors controlling wear. However, only a high strength cast iron can compete with steel in large industrial gears, and this is obtained with alloys and practices which usually increase the modulus of elasticity, thereby defeating the original purpose. The high damping capacity of cast iron is also cited as a desirable property, but our present knowledge of the subject has not enabled any accurate computations to be made.

In the final analysis, any material is evaluated by the cost factor. Cast iron is not the equal of a suitable steel for optimum service in general applications. However, if it can be secured and processed to meet the required conditions in a specialized service more economically, then cast iron must be considered to be a proper material with which to build satisfactory gears. Its usual use is for gears of light unit loading, minimum shock, and low speeds.

Steel is the most widely used gear material

Enormous Gears for Rolling Mill in a Steel Plant, of Alloy Cast Steel, Heat Treated and Then Machined. Over 16 ft. in diameter, weighing over 53,000 lb. as cast

because it is capable of being manufactured and processed to a great many different characteristics, each of which has a definite use. First we shall consider the chemical compositions.

For carburized gears the carbon content usually is within the range of 0.15 to 0.25%. The lower carbons are used to secure maximum toughness; the higher carbons are used for maximum core strength. The recent trend is toward the upper limits; the gears are then used with shallow cases obtained by gas carburizing or activated baths. This trend exactly parallels that in automotive transmissions.

Larger gears, heat treated before machining, have 0.30 to 0.45% carbon range if the steel is to be water quenched, and 0.40 to 0.60% carbon content if oil quenched or normalized (air quenched). Gears which are to be hardened after cutting usually have 0.45 to 0.55% carbon. Carbon content should always approach the upper limit as the size of section or desired core hardness increases. Alloy steels generally have a lower carbon content, which is desirable to increase toughness or to promote their machinability, especially in gears that are cut after heat treatment.

Alloy Steels. Refinements in gear design and manufacture, in conjunction with better steel making practice, have permitted the designer to increase the loadings on the gears, and thus have promoted the use of lower alloyed steel, especially for the smaller gears. On the other hand, the trend in steel mill units, large turbine drives, and crushers, is toward the somewhat higher alloyed steels. The main purpose of alloys is to facilitate the procedure by which the desired properties are obtained. Their particular importance in gear steels is to increase the penetration of hardening and reduce the distortions and internal stresses resulting from heat treatment. Alloys usually increase the ratio of yield point to ultimate strength, and also increase the overload capacity of gears rated on their endurance limit. Alloy gear steels also have better profile durability and strength, particularly against dynamic stresses. Durability is dependent upon surface hardness, and some alloys are available which provide hardness or facilitate the heat treatment for maximum hardness (chromium, manganese and molybdenum).

Maximum resistance to tooth breakage caused by shock or impact loadings is secured with nickel, vanadium or molybdenum.

Fortunately, some alloys and combinations are capable of both improving the profile durability and increasing the dynamic strength and toughness. Usually the combinations follow the S.A.E. specifications fairly closely; the exact percentages are influenced by the size of section and heat treatment required.

Gear steels are usually specified as "fine grained" because of the better dynamic properties and lower distortion during heat treatment. Coarse-grained steels, as determined by standard methods, are given special consideration where the maximum hardenability or machinability is required. Machinability (cost and accuracy) is quite an item; molybdenum, nickel and sulphur are important in this respect, either in normalized or heat treated blanks.

With the proper attention to heat treating procedures, most of the standard steels can be used for definite applications. It is, however, logical for the purchaser's engineers to consult the gear producer's staff and specify those elements which experience has indicated will more easily and economically attain either the hardness, the toughness or the compromise of hardness and toughness required.

Forgings Versus Castings

Assuming that the gear is to be made of steel, the gear metallurgist has a choice between rolled stock, forgings, and castings.

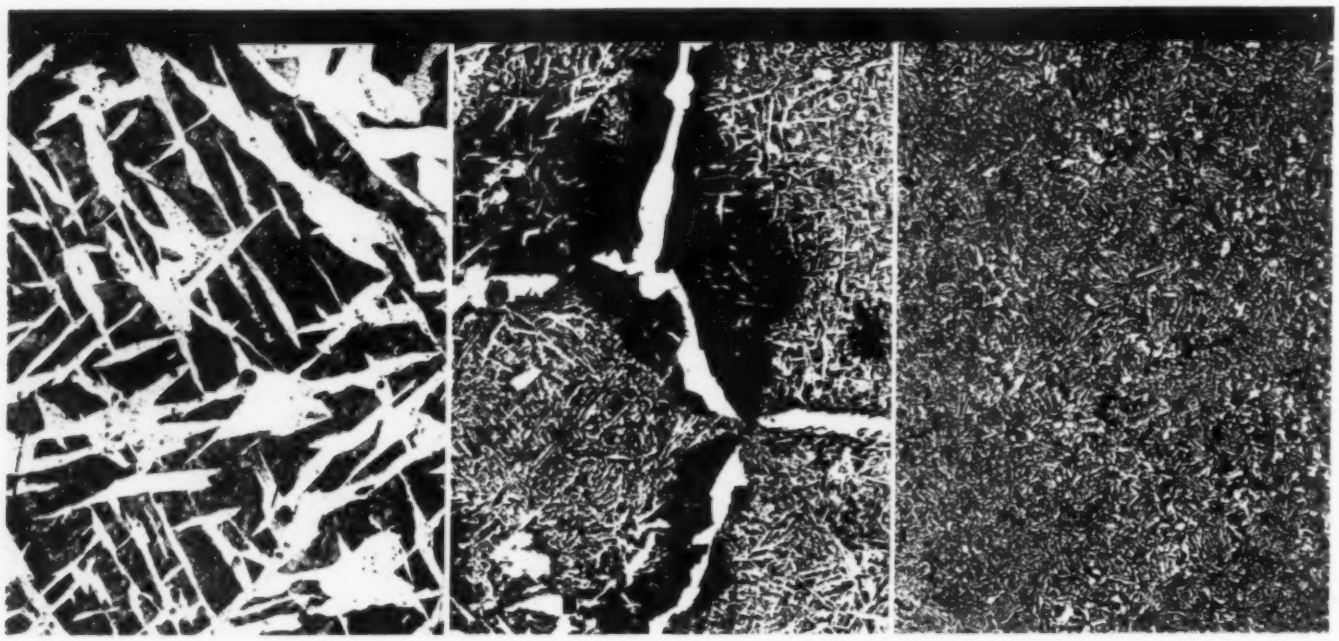
Rolled bar stock is limited to comparatively small sizes of rounds. The manufacturing process causes marked directional properties. The quality of small pinions or gears produced from rolled bar stock is dependent upon the care exercised in the selection of billets, rolling temperatures and reductions to prevent undue segregations, directional faults or porosity.

Round bar stock or rolled flats formed and welded into circular rims have the minimum properties in the direction where maximum loading in bending and shear occurs. This is not particularly detrimental for moderate sizes and duties, but does prevent their use in large, heavily loaded pinions or gears.

Round bar stock is used particularly where the volume of production is not sufficient for the economical use of forgings.

Forgings include steel pieces shaped by a hammer, press, upsetting machine or ring rolling device. Each product has a logical application determined by cost and available facilities.

A forged gear may be specified for one of the following reasons: First, forging can shape



As cast
0.30% carbon steel

As cast
0.40% carbon, 1.25% manganese, 0.20% molybdenum

Heat treated

Structure of Gear Steels in 2-In. Sections, Polished and Etched With Nital and Photographed at 100 Diameters. Heat treatment: Normalized from 1725° F., air quenched from 1550° F., tempered at 1250° F.

a piece more closely to dimension, thereby reducing machining time and eliminating useless metal. Second, forging can refine the structure, a matter particularly important for large sizes. Third, forging shapes the metal to take advantage of the resulting directional properties. It is sometimes possible to obtain all these results in one forging.

Small forgings are shaped by the sharp percussion blows of a hammer or forging machine. When the volume of production is sufficient, drop forgings and upset forgings are made in dies, properly shaped. The most important portion of the forging is the rim in which the teeth are cut; consequently the stock should first be upset to place the "fiber" in proper position, after which attention may be given to getting the exact shape desired.

In many instances, the proper arrangement of fiber or flow lines can only be secured by upsetting the material so the forging fibers have a radial direction, thereby securing the maximum resistance to breakage. The limitation of the upsetting method is determined by the proportions of the large and small diameters. When too big an upset is required on a given shaft diameter, sufficient material cannot be gathered into the upset.

There are applications where only the rim of a gear is to be worked or shaped. For this purpose the stock may be rolled into an annular ring. When a large diameter must be secured with a relatively thin rim, excess rolling will reduce the properties in the direction in which the maximum physicals are required, and experience has proven the wisdom of using steel castings in these borderline applications for heavily loaded gears.

The maximum size of hammered forgings is limited by the capacity of the hammer and the shape of the piece. With the sharp blows there is a constant danger of rupturing large pieces. Therefore, for all forgings weighing upwards of a few hundred pounds, or of complicated section, the metal is shaped by pressing.

As shown in the article by Adolph Schaefer in METAL PROGRESS, March 1939, press forgings are made under large steam or hydraulic presses which form the metal rather slowly. The quality of the forging is determined by the skill of the crew heating the metal and manipulating the press and ingot.

Steel castings are universally accepted as the proper choice for all large diameters, especially for the gear element. Their properties and service are very closely affiliated with the proper correlation between design and founding practice. Especial attention must be given to the quality of the metal in the rim; shrinkage and porosity must be *(Continued on page 778)*

Temperature Measurement and control

Central Pyrometric Control by Bristol Instruments at Canadian Acme Screw & Gear Co.

By John S. Marsh*

THE subject of temperature, neglected since 1919 by organizers of symposia, received a full measure of attention in New York City early in November. "A Symposium on Temperature; Its Measurement and Control in Science and Industry" (under the auspices of the American Institute of Physics and with the cooperation of the National Bureau of Standards, the National Research Council, and an imposing roster of technical societies — including ♋ of course) encouraged no less than 600-odd persons to register in order to hear 127 papers by 150 authors, jammed into 20 sessions over a three-day period. Comparison with the Symposium of 1919 is inevitable, consequently the statistics are completed at once: The earlier meeting considered 60 papers by 57 authors; of these, about 10% emanated from non-industrial laboratories such as the Bureau of Standards and the Geophysical Laboratory, about 40% from industry, about 15% from makers of pyrometric equipment, and the remainder from educational institutions. Industry evidently had been sold already. These same sources were active in 1939, although the educators gained somewhat at the expense of the non-industrialists; but here is the unexpected: Fully 20% of the papers were supplied by physiologists, whereas the closest approach to physiology in 1919 was "Temperature of a Burning Cigar"!

The concept of temperature is fundamental, therefore subtle. The ineluctable result is that precise thoughts are difficult to transfer from originator to receiver, especially if the two operate in different fields — a fact that emerged repeatedly during the mingling of physicists, biologists, engineers, clinicians, professors, technicians, and "practical men". The *word* temperature has had a variety of meanings; for example, when a certain J. Jones wrote in 1579 that "The nurse . . . shall be chosen . . . according to the temperature of the babe" he obviously was not thinking in terms of modern thermometry. And "a vertuous temperature between two vicious extremities" (1599) was hardly composed by the ad-writer of an ancient controller manufacturer. Still another notion is given by a quotation dating back to 1580: "Iron is so harde . . . that being wrought, it serveth for Steele chiefly with a temperature that is given to it."

It is conceivable that any of these state-

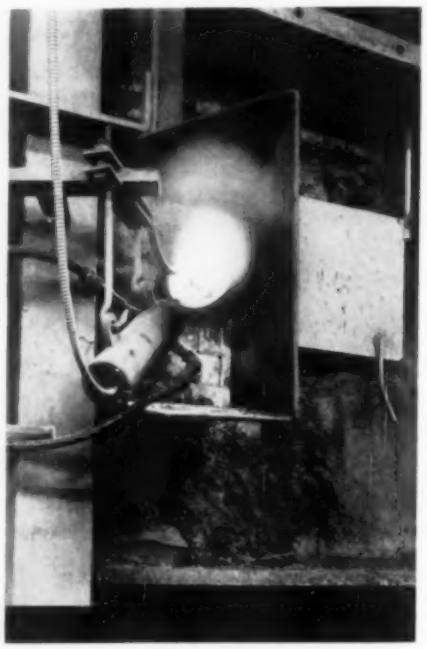
*Associate Editor, Alloys of Iron Research, New York City

ments would be misinterpreted by the layman. But even the technical man, after a bout with bacteria and a clinical thermometer, is likely to say that "he had a temperature". This, of course, horrifies the precisian, but is good idiomatic American language understood by everybody; the matter is of no importance here other than as one of a number of examples that prove that the word is still not defined uniquely. Since there are ambiguities also among the various aspects of measurement and control of temperature, one of the valuable results of the symposium was ample proof that many of the problems of divergent fields are similar; this in turn showed greater inherent unity of the many papers than might have been indicated by their titles.

It was possible to attend only a fraction of the presentations and discussions; a still smaller fraction must be selected for review here.

A session on "Education", occupying a full morning, was well attended by industrialists, as well as educators. P. H. DIKE described the course given salesmen and engineers at Leeds and Northrup; it extends over approximately a year and consists of extensive instruction in temperature measurement and training in other branches of instrumentation. Mr. DIKE asked for more attention to these topics in engineering schools, which were represented by J. M. CORK (University of Michigan) and E. D. HOWE and L. M. K. BOELTER (University of California). Professor CORK's aim is to produce talent "resourceful enough to analyze and solve any problem that might arise in practice. . . ." This is attempted by way of a separate course in pyrometry; Professors HOWE and BOELTER, however, believe in making pyrometry only a part of general laboratory work on mensuration — or, perhaps, a subdivision of a metallurgical laboratory course. It must be admitted that the experiments they have devised are far more interesting than those thrust upon this reporter when he was in college.

Industry was represented by ROBERT B. SOSMAN of the U. S. Steel Corp. His special fame as a molder of phrases must be spreading in metallurgical circles, because the audience-count jumped sharply — nearly all metallurgists — in time for "The Education of a Pyrometrist". It was pointed out that the plant needs two types of pyrometrists — first, "the research man, skeptical of the misinformation supplied by industrial instruments as usually installed and maintained . . . ." and second, the man "whose main interest is to keep the machines operating in something approaching satisfactory style". Dr. SOSMAN enumerated requirements for the first type in terms of WHEELER's forces that drive researchers (curiosity, hunting, collecting, workmanship, and so on). It would be interesting to see the prescription set up for the research metallurgist.



Leeds and Northrup "Rayotube" Looking at the Temperature of an Openhearth Roof

Long discussions of the educational papers concentrate to about this: (1) Industrialists are not wholly satisfied with the current college product; (2) educators are more than willing to take suggestions; (3) the industrialists do not agree on what they want [the standard conclusion of all industrialist-educator conferences attended by the EDITOR]. The educators requested also some worthy problems for research; Dr. SOSMAN reminded them that industry is necessarily chary about divulging many of its pyrometric headaches, but suggested study of the application of electron and photo-electric tubes (which received little attention by authors at the symposium) and the laws of radiation, especially in the infra-red region.

A session on "Thermometric Metals and Alloys" covered an enormous amount of territory. Three papers were devoted to platinum and platinum-metal thermometers and pyrometers; authors and discussers agreed that the quality and reliability of these materials has been increased markedly in recent years. The point eliciting greatest interest was that prior furnace annealing at 750° F. betters performance; none knows why, and no especially seductive guess was advanced. Many new data on base-metal couples were presented also, mostly

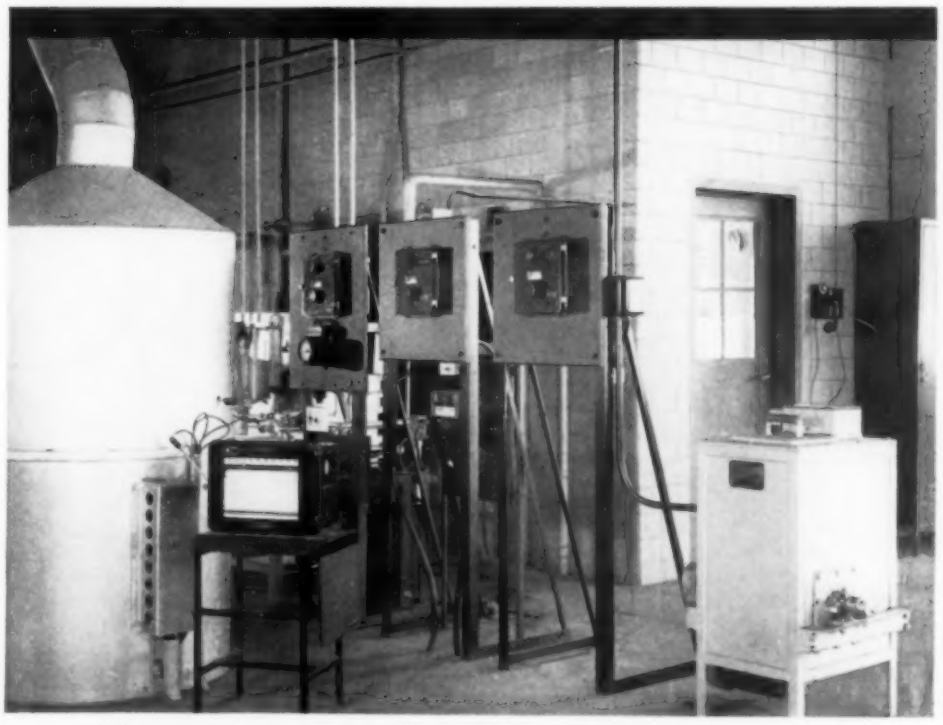
in tabular form, which may be useful to designers of instruments.

What might be called theory had several innings. The matter of temperature and temperature scales was discussed generally by H. T. Wensel of the Bureau of Standards, who included the basis and meaning of a thermodynamic scale and its relation to the several practical scales. Other topics in this category, selected at random, such as "The Proposed New Definition of the Thermodynamic Temperature Scale" and "The Location of the Sulphur and Mercury Boiling Points on the Thermodynamic Temperature Scale", seem rather remote from affairs of the metallurgist, although he may need know on some calibrating day that the boiling point of mercury was reported to be 356.58° C. on the International Scale and 356.73° C. on the Thermodynamic Scale.

Metallurgical pyrometry, as such, was restricted to a few papers on non-ferrous metals and a session on iron and steel. John Chipman, of Massachusetts Institute of Technology, reported that the melting point of iron really is very close to 1535° C. (2795° F.) and produced evidence for the belief that oxygen was probably responsible for lack of agreement among what seemed to be the most reliable of the earlier investigations. Other contributions to the ferrous session were on "The Pyrometry of Liquid Steel in the Openhearth Furnace", by L. O. Sordahl of U. S. Steel Corp.; the use of the non-metallic couple using graphite and silicon carbide, by George R. Fitterer of the University of Pittsburgh; a photronic-cell radiation couple, by B. M. Larsen of the Steel corporation; and a quick-immersion technique devised by F. H. Schofield and A. Grace of the National Physical Laboratory in England. The last authors use platinum-metal couples; their method and its attendant apparatus aroused considerable interest among the steel men. (Details of this equipment are in the eighth report of the Committee on the Heterogeneity of Steel Ingots.)

Methods for measuring the temperature of liquid steel, discussed briefly by Mr. Sordahl, included test spoon, dissolving tube, rod boil, slag bubble, slag surface, and Collins-Oseland tube; he was of the opinion that the Collins-Oseland tube method (U. S. Patent 2,020,019) holds the most promise, but stated that the test-spoon method is as good, if carefully standardized. These measurements are of precision far from that attainable at, say, the boiling point of mercury; in point of fact, in a mild argument during discussion of the value of the trained human eye as a pyrometer for steelmaking temperatures, enough was admitted to disconcert some of the instrumentation enthusiasts. There is much to be accomplished yet in this field.

Thoughts of J. A. Doyle of W. S. Rockwell Co., entitled "The Relation of Uniform Pyrometer Records to Uniform Products", appealed to listeners of widely varied interests. "The relation of evidence and proof, of shadow and substance, is, in effect, substantially the relation of pyrometry and product in industrial heating practice," he said. "Better results will follow when we have men in the shops better educated to practice one of the oldest of industrial arts, which has more



Three Tagliabue Controllers (Photo-Electrically Balanced) for Heat Treating Furnaces, and a 6-Point Recorder, in the Climax Molybdenum Co.'s Experimental Laboratory

influence on quality and uniformity than any other fabricating process. It has its roots in the ceramic practice of the ancients long before the machine age, or even the metallurgical age. The ancient art seems to have been lost in the modern technical complication of thermodynamics, abstract technology, complicated pyrometry — and sales promotion." This was indeed a different theme, sung at a time when one usually hears songs in praise of instrumentation permitting integration of chemical industries, or of devices for close approach to absolute zero. And there was more to come: "It seems strange, that with all our gadgets for control of production, there should be here a quality market for cutlery produced with crude coal fires in the homes of craftsmen abroad who have no conception of pyrometers or automatic temperature control.

"There is need for trained production specialists and supervisors of important heating and cooling operations. The present industrial situation is as though the army had many dietitians to prescribe suitable diets but not enough skilled cooks to prepare the food. . . ."

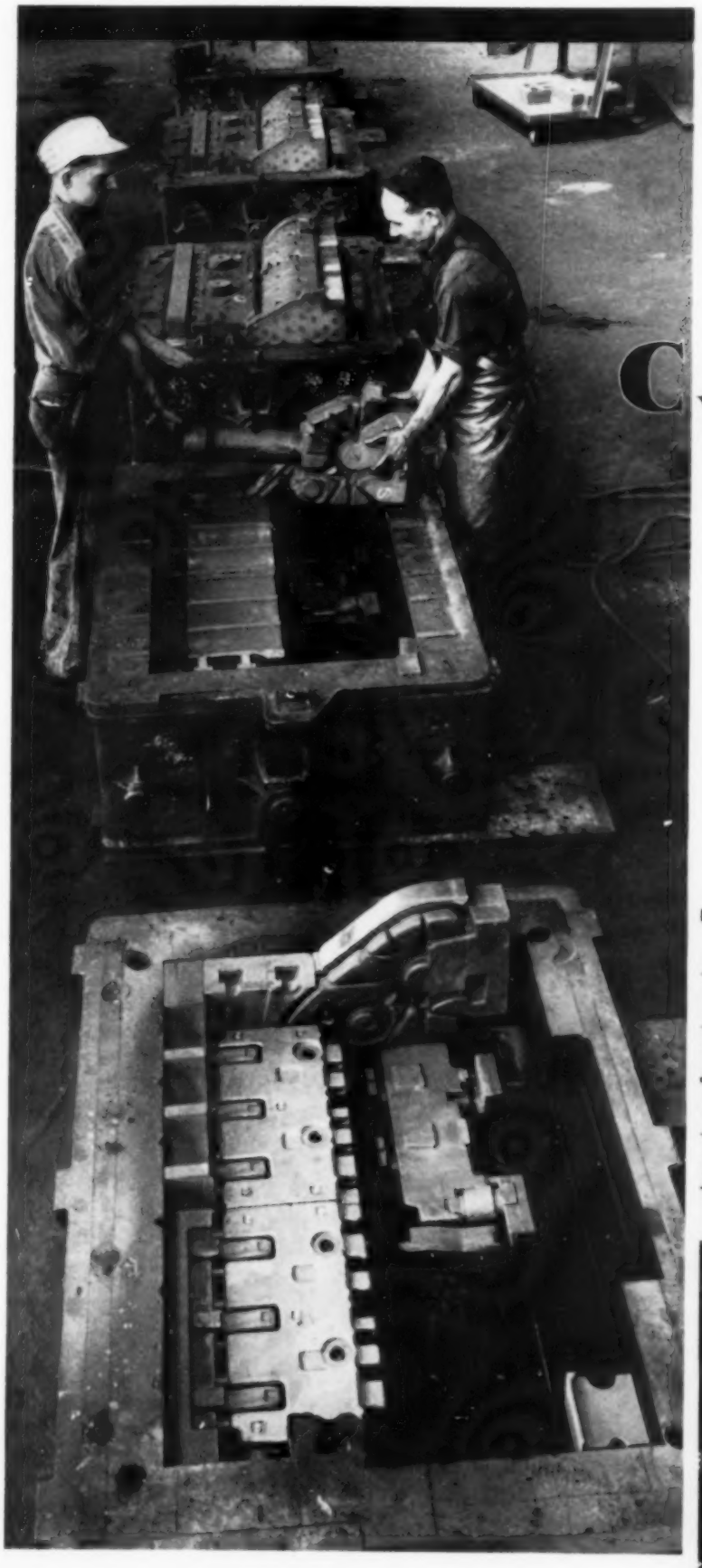
To return from Mr. DOYLE's somewhat philosophic excursion — and to leave strictly metallurgical applications of pyrometry — it may be stated that many readers of METAL PROGRESS probably would have found papers of interest among those on general engineering. For example, in one the use of thermocouples in testing steam turbines was described; others treated such matters as temperature measurement of fuel beds, gases, and flames; there were papers on plastic molding, surface temperatures, air conditioning, and the food industry. Even the sessions on oil production and oil refining could not be ignored, because there was a paper on tubes for cracking stills. The research metallurgist would probably not want to have missed "Control and Measurement of Temperature under the Microscope", by CHARLES P. SAYLOR of the Bureau of Standards, in which experiences with temperatures ranging from —120 to 1100° C. were described. The full-time pyrometrist certainly would have had the sessions on optical pyrometry, special theories and methods, precision thermometry, and automatic control and instruments on his must, or at least maybe, list.

However, as is easily deducible from the statistics given at the outset of this report, preparing the list and following it were two vastly different operations. Single conflicts of schedule are well known to attenders of Metal Congress technical sessions, but here were doubles and triples as well. Loose-ends can fortunately be caught up, because some of the papers will appear in publications of the Institute of Physics and in other journals, and eventually in a complete volume. If the career of the long-out-of-print 1919 volume is any indication, success of a new bound volume is assured.

At the close of the formal proceedings, most of the participants seemed to feel that the symposium had been a very useful undertaking. A few dissenting voices were heard, including that of an active worker in the 1919 meeting, but it usually developed that the pessimists had heard no discussion of pyrometric problems connected with their own special products. It is true that the seeker of information on a single product or thing had a chance of being disappointed, but not much of a one, for there was even a paper on temperatures of volcanoes, fumaroles, and hot springs!

Incidentally, persons well known to ⛑ members were prominent in organizing the symposium: C. O. FAIRCHILD was chairman of the general committee and ROBERT B. SOSMAN was chairman of the committee on metal industries.

Controllers and Recorders for a Non-Ferrous Mill (Courtesy the Foxboro Co.)

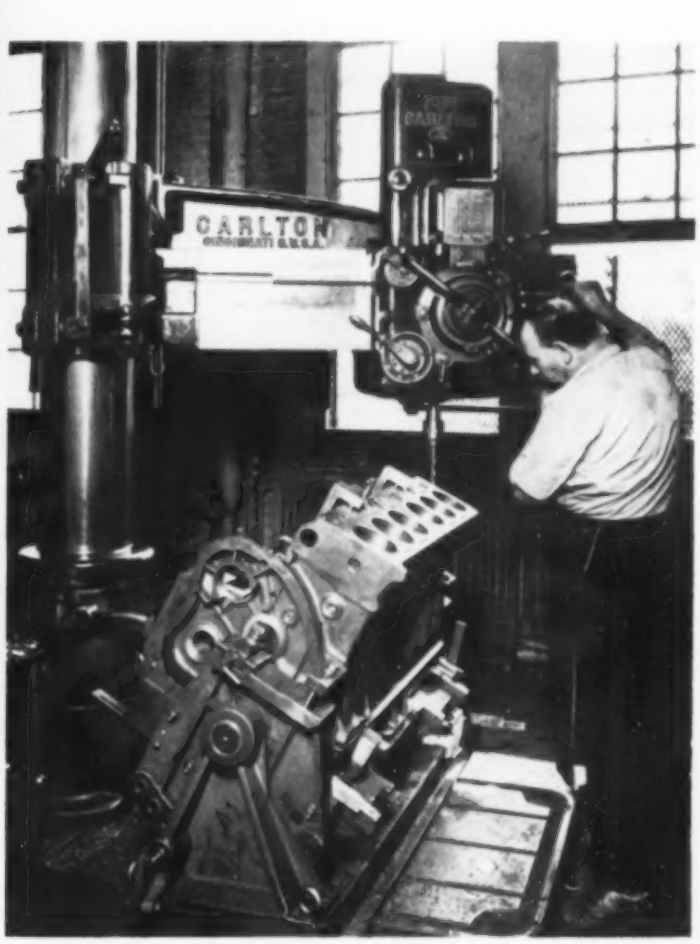


Alloy Iron Cylinder Blocks for truck engines

A pictorial story of operations at

Mack Manufacturing Corp.

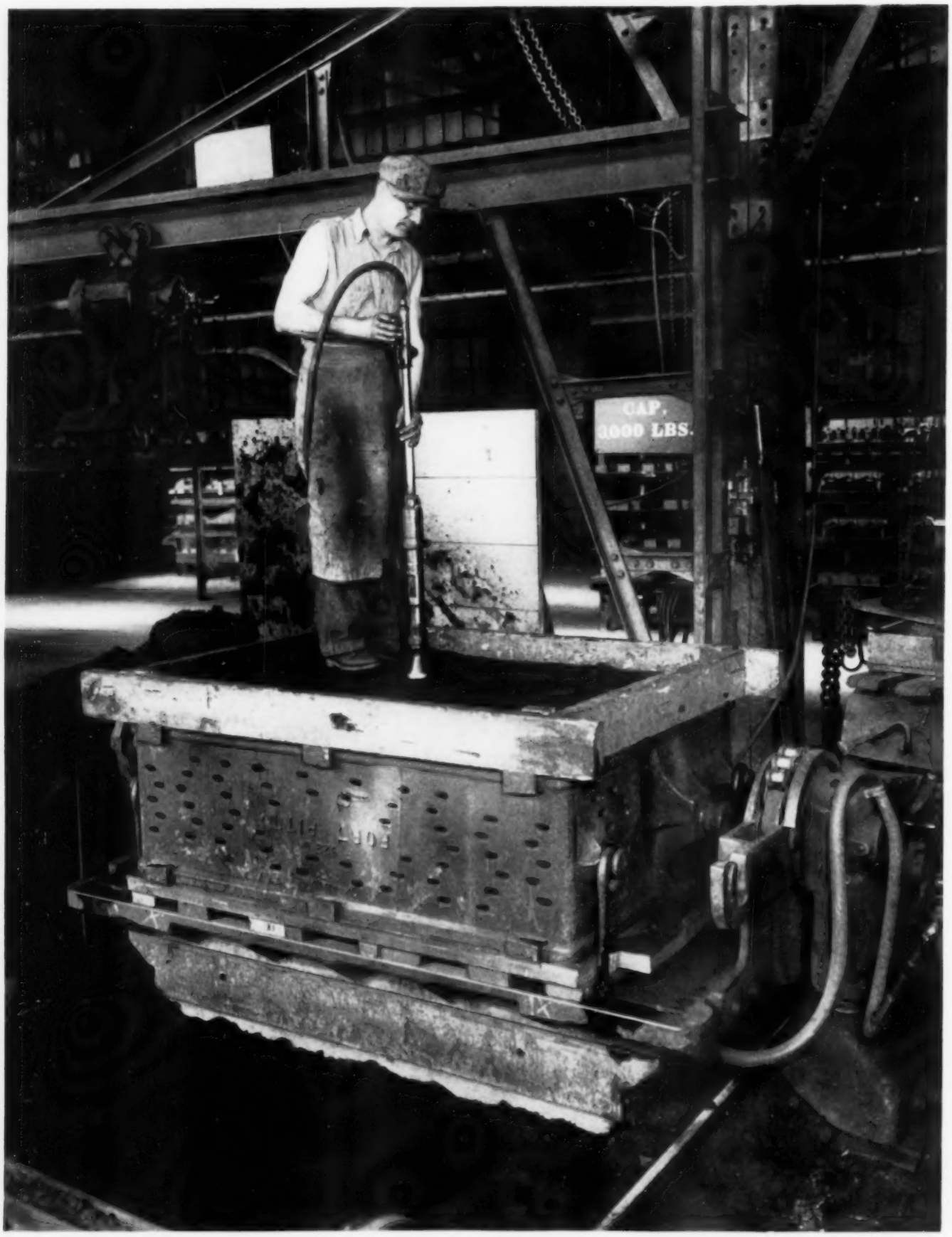
New Brunswick and Plainfield, N. J.



Photographs by Davis Studio

Jersey City, N. J., for

The International Nickel Company, Inc.



CYLINDER BLOCK for a heavy duty six-cylinder truck engine requires a jolting machine, about as large as they come, to ram up the cope and the drag. Sands, which pass the standard tests for texture, porosity and moisture content, run into the flask from overhead storage bins.

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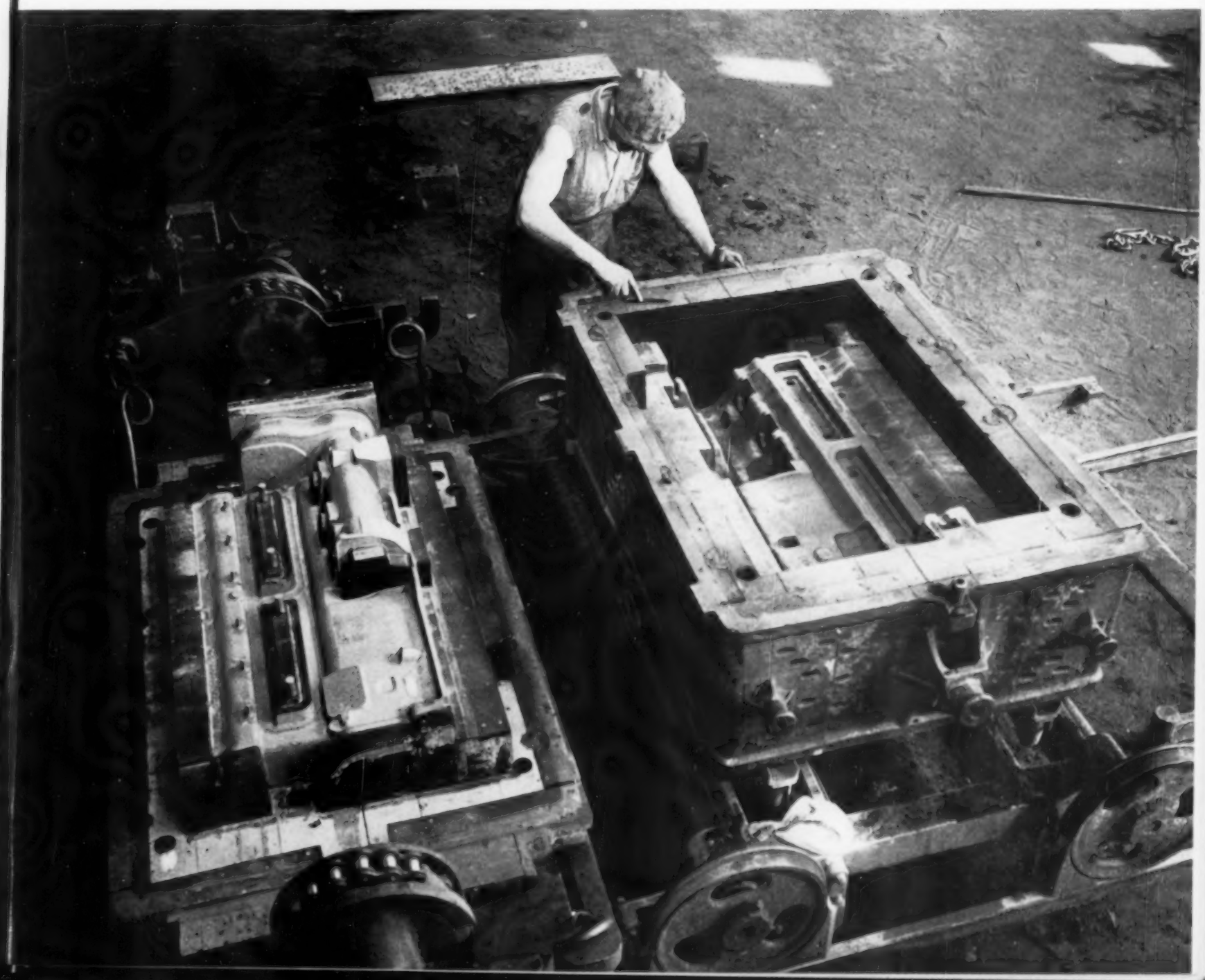
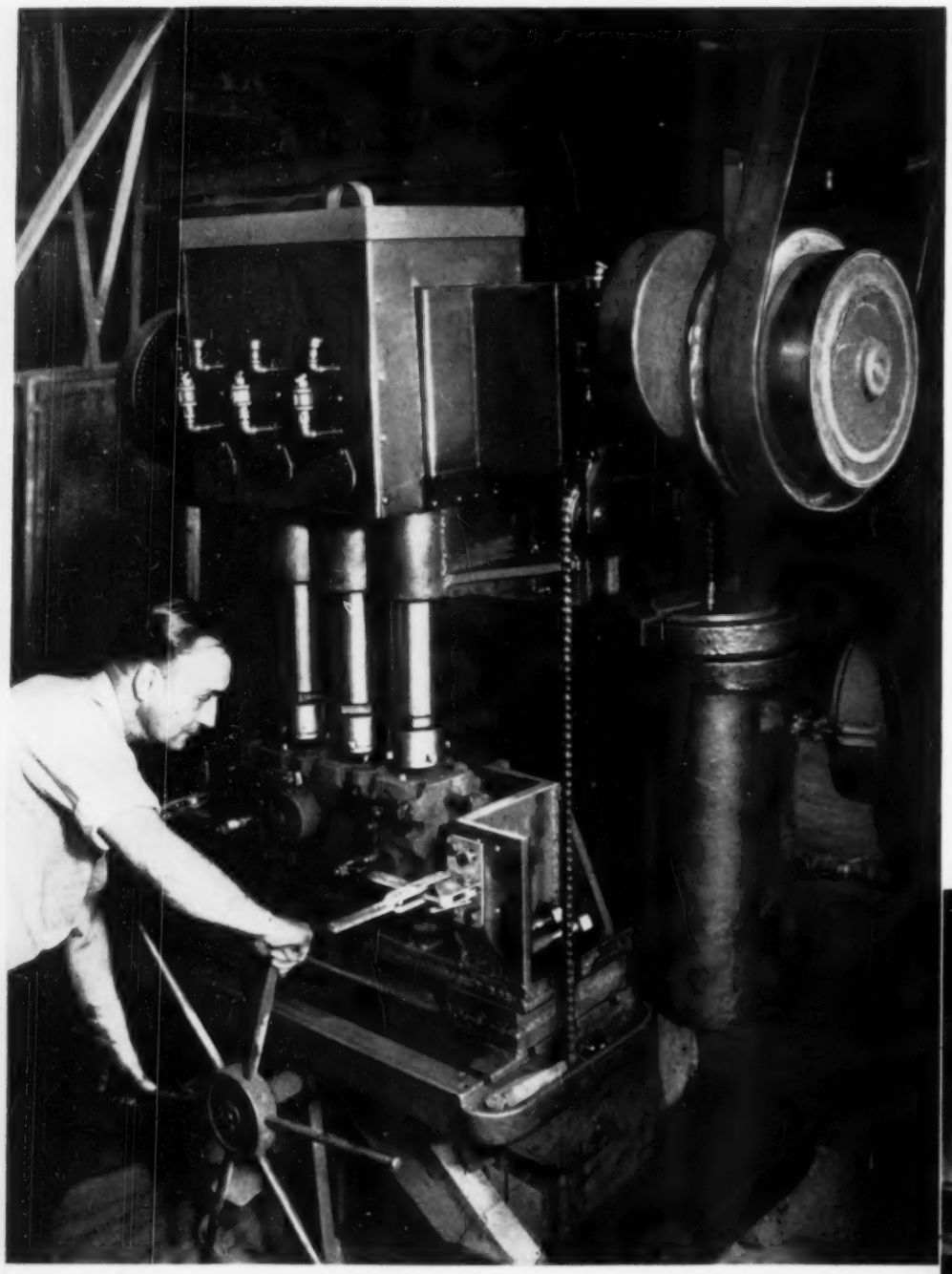
Despite the aid given him by modern molding machinery, rugged flasks, accurate patterns and carefully blended and prepared sands, the preparation of a large and intricate drag for such a cylinder block requires much expert care of a skilled artisan. As will be seen in the sequel, from this point on the mold is an assembly of many cores, and if they are to fit accurately together this foundation must also be accurate in all respects. Once reaching its position on the pouring floor the drag is carefully leveled up and the molder uses a blow torch to skin-dry those surfaces that tend to gas a little when the molten metal strikes them.





B However, it required a toolmaker, assigned to the foundry as assistant supervisor, to bring this idea of accuracy to a practical operation. Some of the methods in use are shown on these two pages. At left is a machine for boring centers in matched pairs of cores for water jackets; cutters are of cemented carbide and accuracy is on the order of 0.002 in. Note the well-designed jig for accurate centering. Workman shown below is placing one half of a barrel core on the bed of a grinder; mating pairs are then pasted together ready for the mold.

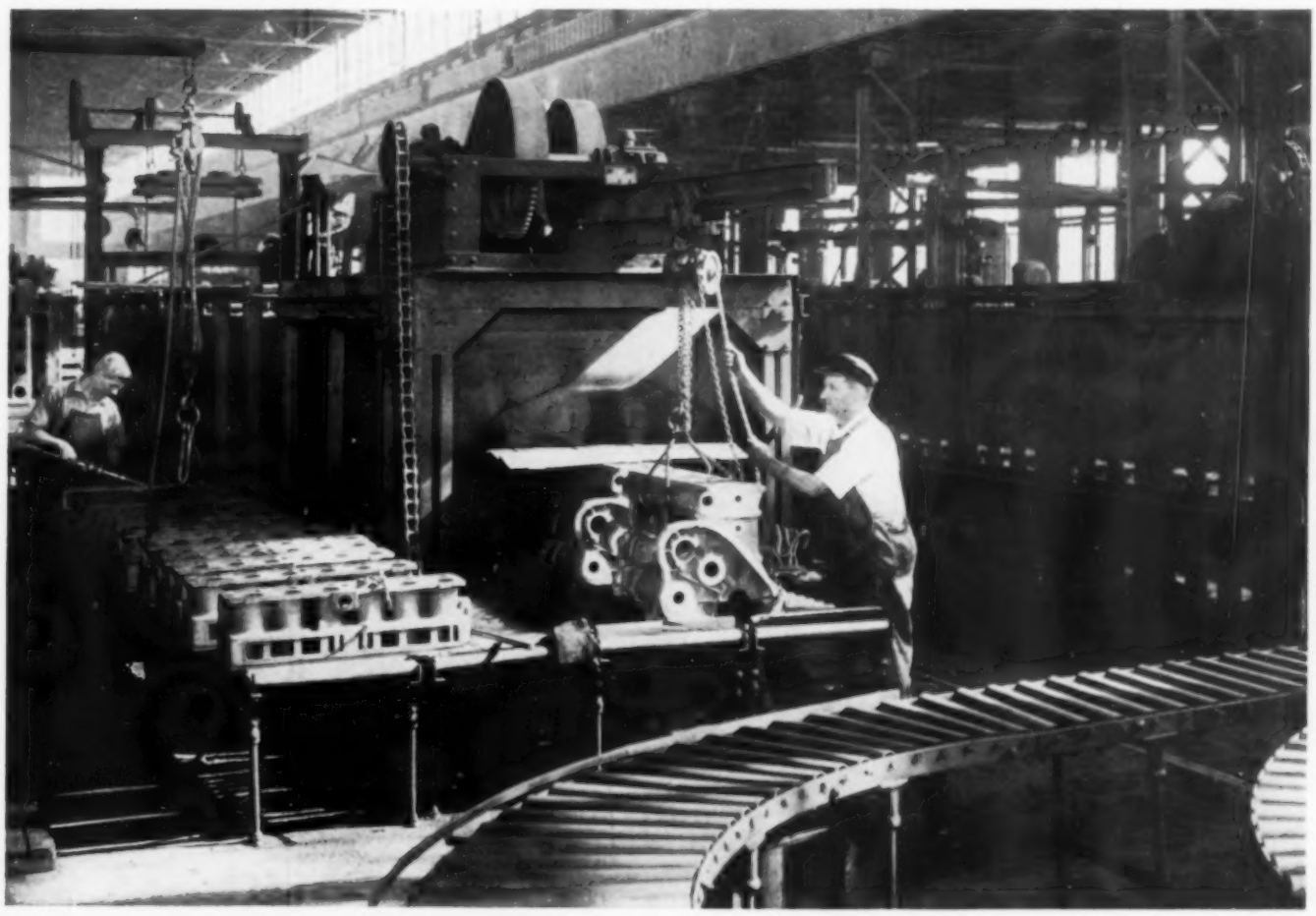
A Engineers of Mack Manufacturing Corp. have long held the premise that accuracy on the molding floor will pay dividends. It enables them to reduce wall thicknesses of water jackets with assurance of uniform metal, not too thick, not too thin, thus improving heat transmission and saving about 15% of the net weight. It enables them to reduce machining allowances, and save correspondingly in the machine shop. It even enables them to core holes in heads and flanges to 0.010 in. tolerance.

Seventy cores are required for a single engine block and 25 more for the head. Here the molder has placed one of the cylinder barrel cores in the mold, and is carefully checking it for position by scale and straightedge. (Note the steel templet with stops on its upper face that has been placed on the flask and centered by its machining pins.) Prior to this operation, the lower half of three water jacket cores has been placed and carefully adjusted by templet.

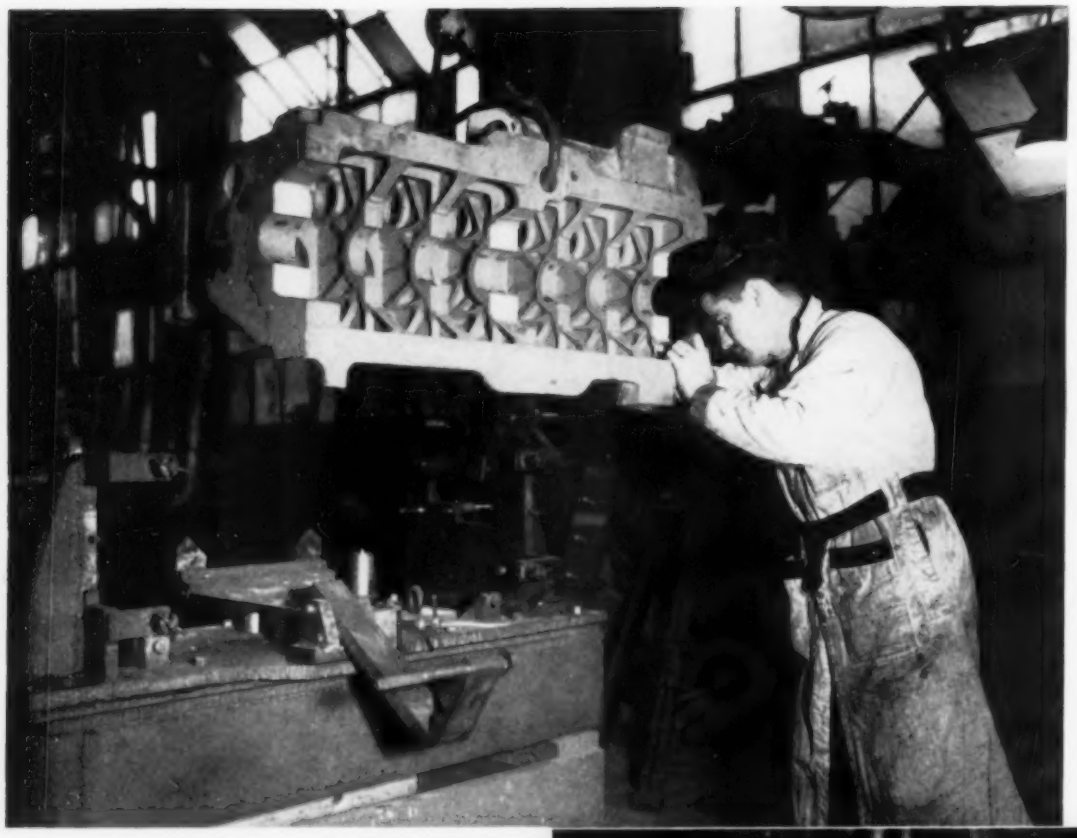
Once the mold is prepared, then comes the problem of making a sound casting having these intricate passages, machinable yet wear resistant. The automotive industry has long relied on nickel and chromium additions to give these essentials to a mixture of gray iron and steel, cupola melted. Mack trucks have, however, used a tougher alloy material for brake drums since 1931, so a 2% nickel, 0.25% chromium addition is readily handled in the foundry. Ingot metal and alloy briquettes are added at the charge floor. Since strength and machinability (that is, graphite size and distribution) of the finished casting depend on the melting and pouring temperature as well as the analysis, the temperature of the alloy iron is measured as it is tapped from the cupola; molten iron is held in these covered ladles the correct time so that uniformity in pouring is constant.

A little metallurgy: Conflicting requirements of machinability and strength (that is, hardness and wear resistance) are almost impossible to meet in plain gray cast iron. If a dense, low silicon iron fairly high in carbon is cast, it must be annealed before it is machinable at the speeds demanded in mass production. To make such metal castable in thin sections around water jackets, silicon would have to be high, and this increases the solidification shrinkage, hence the liability of leaks under hydraulic test. Nickel strengthens and stabilizes the pearlite matrix rather than forms hard carbides. Hence the Brinell hardness of the cylinder iron may be increased to 225 or even 250 without impairing machinability, and the graphite flakes are smaller and more uniformly distributed. With a little chromium the hardness is further increased, and this nickel-chromium combination eliminates the tiny spots of hard iron carbide and prevents the tendency of thin sections of a non-alloy to chill. Stable ferrite, small graphite flakes uniformly distributed, and freedom from iron carbide segregations are all microstructural characteristics that improve wear resistance.

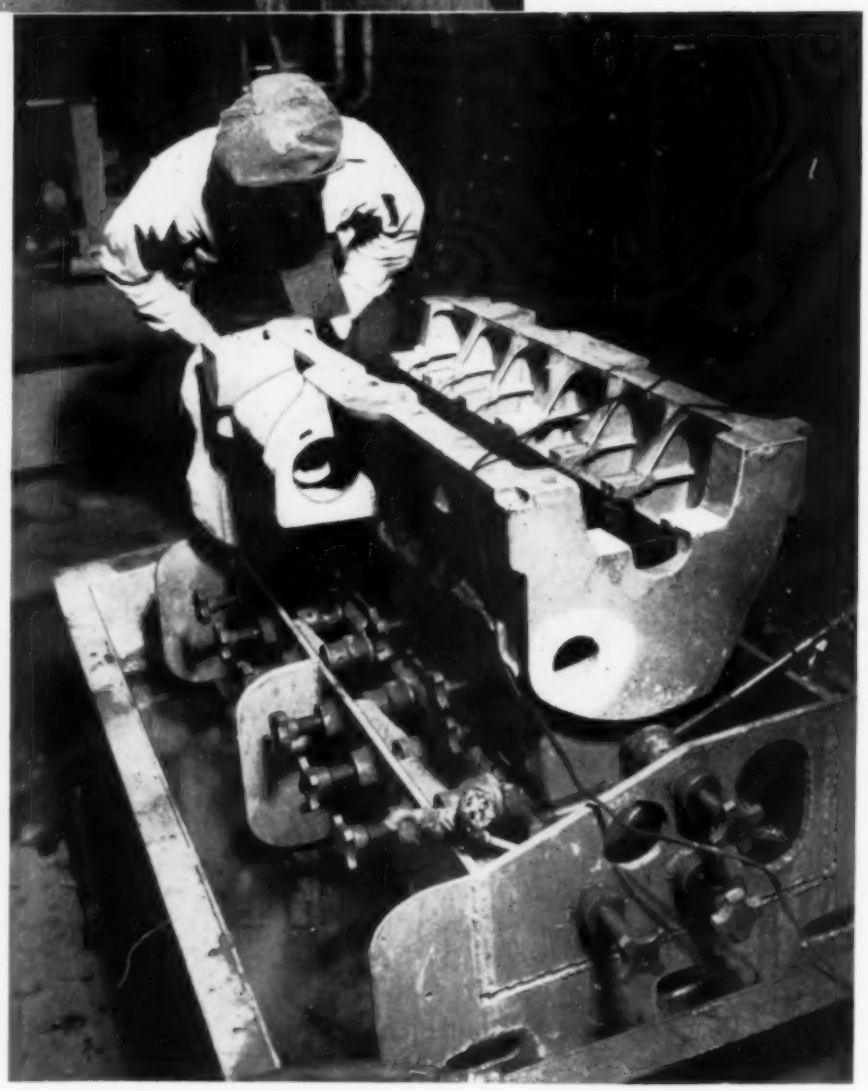
Sandblasting Overhead Valve Motor Heads (Three Cylinders En-Bloc)



Cleaned castings are given a 12-hr. stress relieving heat treatment at 900° F. in these 50-ft. electric furnaces. This stabilizes the metal so that alignment and fine accuracy of machined dimensions in the finished motor are maintained during operating life.

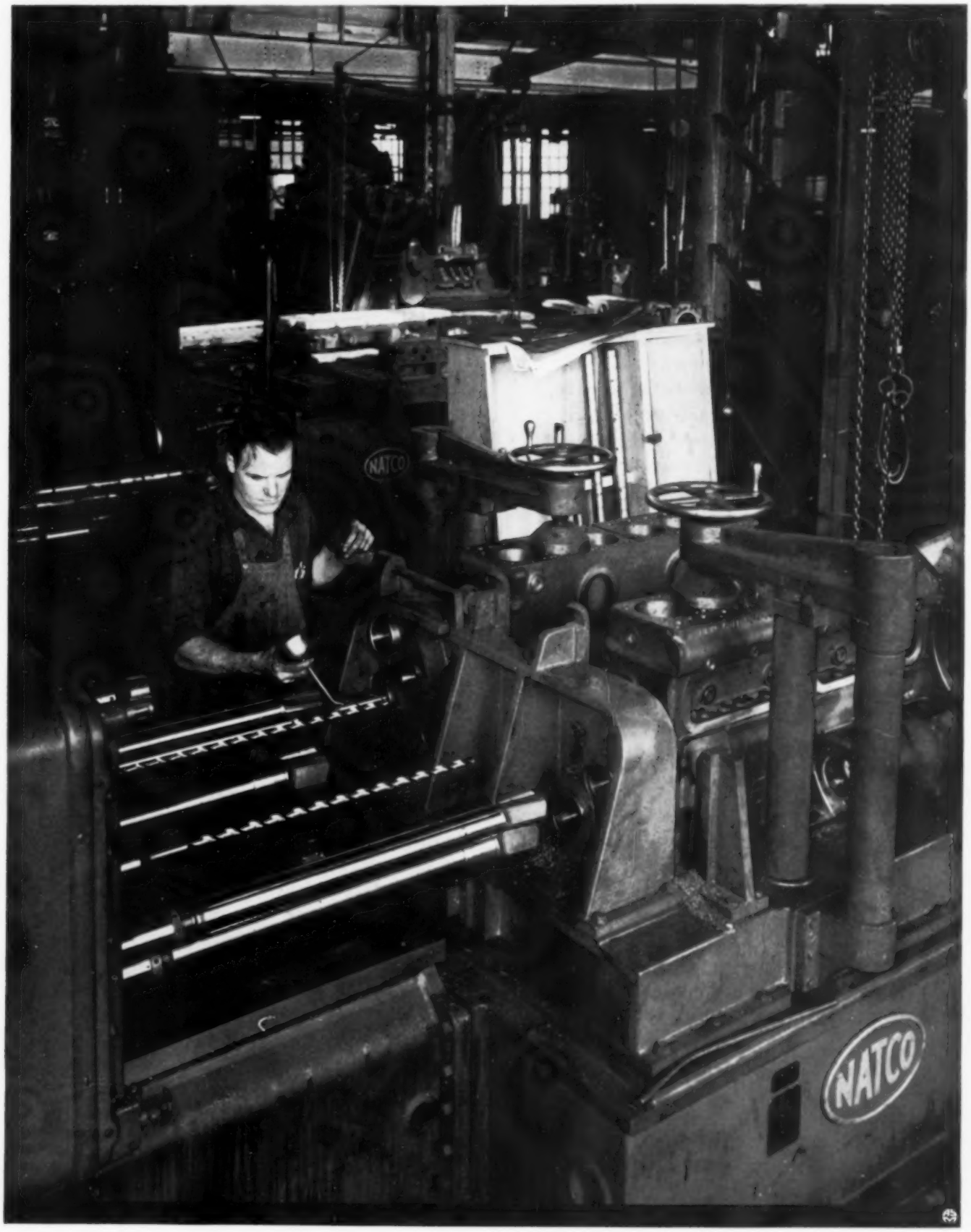


After principal reference surfaces are touched up with a grinder on those spots where fixtures are to be clamped for the first machining operations, the rough casting is lowered on a target fixture for checking all cored holes and the position of critical surfaces. This fixture, with its auxiliaries, is designed to check a casting in one minute, and clear it for the machine shop.

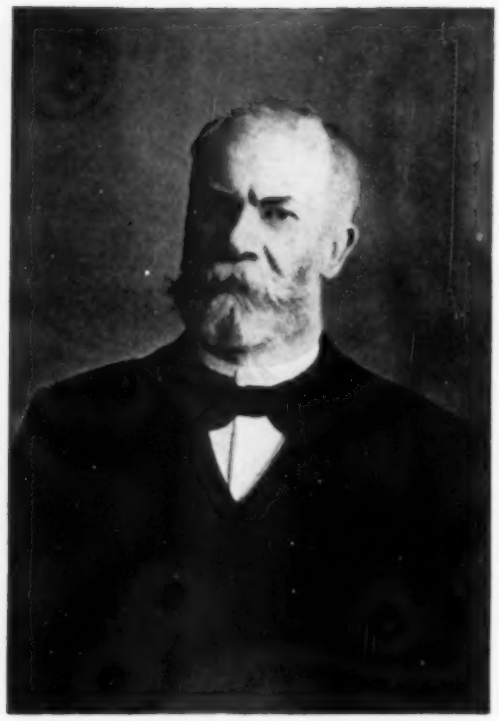


But first all water passages must be proven water tight. In this test-rig all open holes leading to the jackets are plugged and water at 90 psi. injected. No loss of pressure (leakage) can be tolerated. Low silicon irons, containing 1 to 2% nickel, low in solidification shrinkage, enable the foundryman to cast thin walls alongside heavy ones without porous regions at change in section.

Drilling for oil lines and rough boring for crankshaft and camshaft bearings, idler gear and magneto holes is only an indication of the enormous amount of fine machine work to be done on the cylinder block and its head, and emphasizes the need for machinable castings. This alloy iron of satisfactory hardness and wear resistance can be drilled at 130 ft. per min. whereas 80 would be considered good on a plain gray iron of equivalent microstructure.



Tschernoff's Centenary



Dimitry Tschernoff
1839 - 1921
Pioneer Russian Metallurgist

A HUNDRED YEARS AGO artillery (field guns, siege guns, coast defense and naval cannon) was made either of the traditional bronze or the more "modern" cast iron. The bronze was more commonly called brass, even though the usual alloy was 90% copper and 10% tin. Owing to the inherent limitations of these materials the powder charge had to be moderate and artillery therefore had a short range and low accuracy. Efforts to improve the strength of the tubes took the form of placing hoops of iron or steel around the breech, thus increasing the strength against bursting.

Steel available at that time was either cemented bar or crucible cast. The difficulties of making large guns of this stronger material were great; nevertheless the Russian pioneer, Colonel OBOUKHOFF, devised a workable method and founded a plant in 1863 for their manufacture. Some of them were quite satisfactory, and there was not the slightest doubt as to the excellent potentialities of steel as a gun material, but as often as not some of the other guns were thoroughly bad, and no one actually knew why.

Such was the problem that confronted a young instructor in mathematics, DIMITRY KONSTANTINOVITCH TSCHERNOFF by name, taken from the Petrograd Institute of Technology to become what we would now call metallurgist of the forge plant. He found in the crucible shop seasoned old workmen brought from the Urals, some of them carrying the old Anossoff tradition of steel making; there were also experienced English foremen in the forging department. Young TSCHERNOFF spent night and day at the forge, experimenting with samples of differently treated forgings, talking to old workmen and, in their company, training his eye to gage correctly the temperatures of the cooling billets.

It was in the course of these experiments, conducted single handed among the din and noise of a big steel plant, but carefully noting all observations and recording results, that TSCHERNOFF made the discovery of the critical temperatures in steel, which was destined to become the nucleus of what we call the science of physical metallurgy. Since 1939 is the centenary of the birth of this great man, there is ample reason now to recall the circumstances of the discovery and the later events in his life.

This momentous discovery was published as an addendum to "A Critical Survey of the Papers of Lavrov and Kalakoutzky on Steel Guns, and His Own Researches on Same", presented to the Imperial Technical Society. This was in 1868, a year momentous in the history of Russian culture, as MENDELÉEFF published in that same year his Periodic Law of the Chemical

By Nicolas T. Belaiew
Consulting Engineer, Institut de Soudure Autogene, Paris, France

Elements, and TOLSTOY wrote "War and Peace". Of the importance of this discovery in the Obouk-hoff forge, HENRY MARION HOWE, in his monumental work on "The Metallography of Steel and Cast Iron", says "Next in value to the discovery of these steel making processes comes the birth and rapid growth of the new science of metallography, which .... set the metallurgy of iron on a scientific basis .... The first very important step was taken by TSCHERNOFF, who in 1868 enunciated the chief laws which govern the metallography of iron."

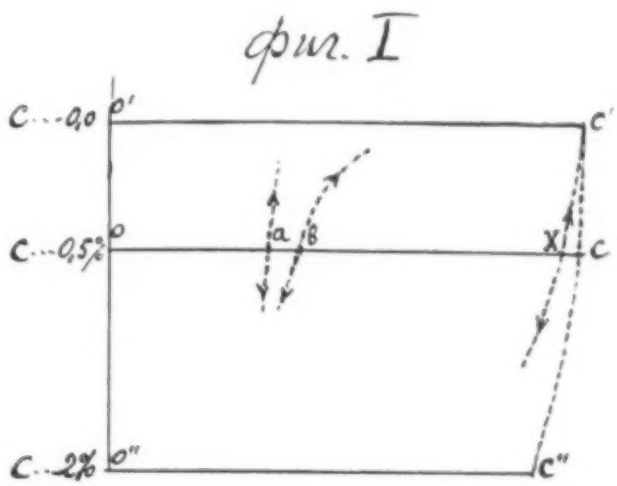
In this early address TSCHERNOFF started his remarks with the observation that what he wanted to show was the influence of the thermal treatment on steel and the relation between the forging and quenching temperatures and the grain of the finished product. He drew before his audience a graph (the one we show was reproduced by him in 1916) where, on a scale like a thermometer scale, several temperatures were plotted from the point *o*, the freezing point of water, to the point *a* corresponding to a dull red heat, point *b* full red heat, and a point *c* the melting point of the steel. These points, he said, vary within certain limits, moving up for low carbon steels, and down as the carbon content increases. The significance of these points was defined by him as follows: "Steel, however hard, if heated to a point below *a* cannot be hardened, no matter how quickly cooled; the steel heated to below *b* does not alter its structure whether slowly or quickly cooled, but, if heated above *b*, the steel changes its structure from granular to amorphous, which it retains during further heating, even up to point *c*."

(The present writer would interject the following interpretation of "granular" and "amorphous". TSCHERNOFF and his disciples intently studied the coarse crystals found inside ingot cavities, the granular structure of sound steel castings and the wonderful markings on Damascus swords. The much finer crystallization in a refined steel structure is visible only under a microscope — then and for 30 years an unused instrument — and was therefore unrecognized; the refined structure was called "amorphous" in contrast with the macroscopic crystallization called "granular".)

The practical importance of the *a* and *b* temperatures is very great, as by determining the former it was possible to find the minimum quenching temperatures for hardening, and the latter gives the minimum temperature for refining the structure. In order to fix this refined austenitic grain (as we call it now), TSCHERNOFF recommended in this paper to cool the billet in water to just below the point *a*, that is to a dull brown. As pointed out by HOWE, all our present-day heat treatments — quenching in oil, quenching in water, air cooling or normalizing, the double heat treatment — are based on TSCHERNOFF's precepts.

The audience was also aware of the importance of the principles laid down; the paper started violent discussion. The president, the famous mineralogist GADOLIN, professor at the Michael Artillery Academy, in summing up the proceedings drew attention to the extraordinary scientific manner in which the researches of the young works engineer were conducted. TSCHERNOFF himself was well aware of the importance of this meeting and his concluding words were: "The forging of steel — in its forward movement — will not deviate from the path where we put it today, gentlemen."

And so it was. The *Proceedings* of the



Tschernoff's Diagram of 1868, Redrawn by Him in 1916 to Show the Correspondence Between His Critical Points a *and* b *and Osmond's Points* A_1 *and* A_3

Imperial Russian Technical Society then had a rather wide circulation in Russia and also abroad. The principal steel plants, Krupp among others, very soon got acquainted with TSCHERNOFF's work, and the improvement in gun manufacture and in armor plate fabrication was immediate and lasting. The engineering world, however, had to wait until 1876, when W. ANDERSON translated this paper under the title of "Remarks on the Manufacture of Steel and the Mode of Working It". Copies of that paper were privately distributed among his friends and those interested in the metallurgy of steel. In 1880 an abstract was also printed in the *Proceedings* of the British Institute of Mechanical Engineers, and a complete French translation in the *Revue Universelle des Mines* (reprinted in *Revue de Métallurgie*, 1915).

The scientific importance of the 1868 paper is of no less consequence. It is sufficient to say that TSCHERNOFF's two critical points *a* and *b* (in the form adopted by OSMOND and designated by him for typographical reasons A_1 and A_3) are the foundation of our present-day equilibrium diagram of the iron-carbon solid solution (steels). LE CHATELIER's pyrometer did not exist at that period and experiments with BECQUEREL's thermocouple did not give satisfactory results when working in a big steel plant. So TSCHERNOFF had to rely on the skill of the old workmen and on his own trained eye. Thus his critical points were determined as "dull red heat" and "full red heat", which are terms familiar to a foreman in a steel plant or a forging shop. Still, one must not forget that at that time the skill of the melter and foreman was very high and that for practical purposes TSCHERNOFF's definitions were quite satisfactory.

The complete identity between the points *a* and A_1, suggested by TSCHERNOFF and OSMOND has never been seriously questioned. However, TSCHERNOFF always insisted that he defined the transformation taking place at *b* as one of change of structure or as a "refining" temperature, and that the processes involved were more complicated than a mere allotropic change. He always experienced difficulty in accepting OSMOND's views on allotropy *in toto*, as he strongly realized the importance of carbon and other elements and their influence on the lattice structure and on the polymorphic transformations of iron. These considerations also led TSCHERNOFF very early to the introduction of two more critical points, *d* and *e*, which he placed at 200 and 450° C. He defined these as the range to which a sample of steel heated above *a* had to be cooled *rapidly* to get a quench. We know now that these points correspond to the suppressed transformation points Ar′ and Ar″ first measured in brilliant experiments with quenching solutions, about 25 years ago, by PORTEVIN and CHEVENARD.

Thus TSCHERNOFF was very much ahead of his time. As with many pioneers, his work and his name became temporarily dissociated. He left the gun factory in 1880, and for several years devoted his talents to geology — discovering and developing an important deposit of rock salt, which made him economically independent and again able to devote his attention to metallurgy. Returning to St. Petersburg he was "discovered" by General DEMIANENKOFF, director of the Michael Artillery Academy, who appointed him to be professor of the new chair of physical metallurgy (1889). Fame then came, slowly but surely, to TSCHERNOFF and he was hailed at all international gatherings as "The Father of the Metallography of Iron". His other work had to do with the primary solidification of steel, wherein he was able to secure unmatched fir trees 10 in. long, the erosion of guns, the manufacture of projectiles, the bessemer process, and the production of steel direct from ore, and the ancient art of steel making as exemplified by armor and Damascus swords.

More important was his profound influence on his many students, among which the writer proudly numbers himself. I shall also never forget that house in the suburbs, where TSCHERNOFF lived with his family and his books, in a kind of estate as a country gentleman, and still at a stone's throw from the avenues leading to the center of the town. In one of the buildings was his laboratory and his library. It is there that he loved to show his famous collection of Damascus blades. He would bring out a violin of his own make and compare its tone to one of his Stradivarii, or take from one of his portfolios some photographs of snow crystals and illustrate by their growth the dendritic crystallization of steel. In lighter moods he would bring out a bottle of his famous elderberry wine, from the fruit of his own garden, and start a dissertation on some subjects dear to his heart. He lavished attention on all his pupils. Seldom did a young artillery officer, on leave, fail to visit the revered old gentleman. Everyone came to him with his private worries — scientific, technological or personal — and none left empty-handed, but soul and body refreshed.

Sulphide Inclusions from clay packing

By George K. Manning*

RECENTLY some small carburized parts, which had caused processing difficulties, came to the attention of the Republic Steel Corp.'s laboratory. Only the outside surface of these parts was carburized, the splined bore having been packed with clay and sealed at each end with a steel plate and a liquid, used commercially to prevent carburization. Some of these parts were quenched direct from the carburizing operation. After quenching and removing the packing from the core, spalling was observed on the internal spline of the direct quenched parts.

Other parts were packed in a similar manner, but furnace cooled from the carburizing temperature; a subsequent welding operation was performed on the inside surface of these parts, whereupon a boiling effect was produced in the weld metal and the finished welds were unsound.

The micro at the head of this article shows, at 150 diameters, an unetched cross-section through one of the inside surfaces. Those areas appearing light gray in the photomicrograph were actually a pale yellow color.

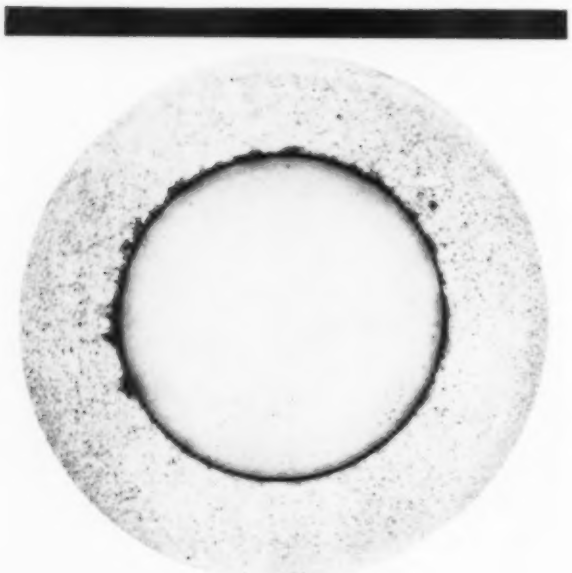
In making various tests to determine the nature of these yellow inclusions, it was found that a 10% aqueous solution of chromic acid (H_2CrO_4) lightly attacked the dark gray and black areas in ten minutes' time, but left the yellow areas unaffected. A subsequent etch in boiling alkaline sodium picrate removed all of the inclusions. As shown in the "Method for Identification of Inclusions in Iron and Steel", data sheet in October's METAL PROGRESS, page 444, these tests indicated that the troublesome layer was full of iron sulphides and a sulphur print of a cross-section (shown on the next page) confirmed this indication. Filings taken from this inside surface analysed more than 1% sulphur!

A sample of the steel used in these parts was carefully cleaned in carbon tetrachloride, then packed and sealed in the same clay and heated for ten hours at 1700° F., the carburizing temperature, in an electric furnace. The same high sulphur layer was apparent after polishing a cross-section of the sample. Analysis of the clay then showed that the sulphur present

*Metallurgical Laboratory, South Chicago Plant, Republic Steel Corp.

as sulphide was nil, but that the sulphur present as a sulphate was 0.23%. Further analyses indicated that aluminum was the principal metal bonded to the sulphate radical.

To determine if other forms of sulphur might also be capable of sulphidizing the same steel, samples were dipped in high sulphur cutting oil, packed and sealed in a clay known to be free from all forms of sulphur, and heated for ten hours at 1700° F. The sulphide layer was again evident on the steel, though in this instance it was confined to a depth of 0.002 in., while with the sulphate bearing clay it had penetrated to a maximum depth of 0.010 in.



Sulphur Print of Steel Tube Carburized Outside but "Protected" Inside by Packing With Clay Contaminated With Aluminum Sulphate

It is significant that after packing with clay the ends of the defective parts were rather thoroughly sealed. Therefore, the oxides of sulphur formed by the decomposition of the aluminum sulphate in the clay at the carburizing temperature probably built up to a very considerable concentration. Although the clay contained less than 0.25% sulphur, all of it was available at the steel-clay interface, due to the fact that the decomposition product of the sulphate was gaseous and could not escape.

Zinc alloys for hot working

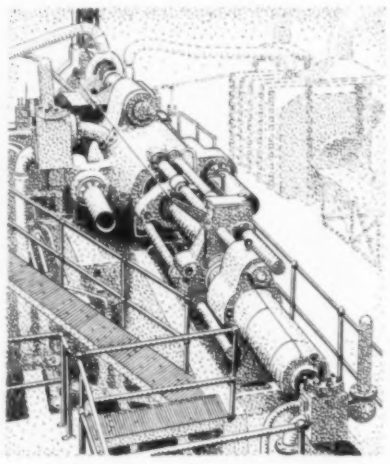
By J. Raber and E. Schmid

Abstracted from The Metal Industry, *Oct. 13 and 20, 1939, page 239 and 345*

SOME years ago, experiencing a continuous shortage of copper and brass, the German metal industry turned to zinc (of which there are readier supplies) for a suitable substitute. An intensive search was made for the most important alloying elements in order to strengthen and toughen the relatively weak, brittle zinc.

The most important alloy addition to zinc is aluminum, which is added in quantities up to 10%. It is extraordinarily effective in decreasing the grain size of the material, simultaneously hardening it; the castability is improved, and the amount of iron taken off from the crucible is decreased if the additions of aluminum are only very small.

[Examination of text and of the equilibrium diagram in Metals Handbook, page 1738, shows a eutectic melting at 715° F. between alpha solid solution with less than 1% aluminum in zinc and beta solid solution of 21% aluminum in zinc. At 520° F. this beta solid solution tends to change into a gamma solution of the same crystallography, but containing 65% or more aluminum. The alpha solution has the crystallography characteristic of zinc, namely the hexagonal close-packed with a few aluminum atoms substituting for zinc atoms, whereas beta and gamma are both substitutional solid solutions in the face-centered cubic crystal characteristic of substantially pure aluminum.]



The alloying metal second in importance is copper, which is at the moment added up to 4% in the forgeable alloys of zinc. Copper also causes hardening and a decrease in grain size; at the same time it improves the corrosion resistance. The latter is also improved very much by minor additions of magnesium. Even quantities of only some hundredths per cent eliminate the grain boundary sensitivity

(Continued on page 782)

Properties of Commercial Copper

From "The Commercially Important Wrought Copper Alloys," by Chase Brass & Copper Co.

Chemical and Physical Properties

Name	Composition	Density; Lb. per Cu. In.	Melting Point; °F.	Coefficient of Thermal Expansion; Average 25° C. to 300° C.	Electrical Conductivity; % I.A.C.S. (Annealed)	Thermal Conductivity Cal./Sq. Cm./Cm./Sec./°C. at 20° C.
Electrolytic tough pitch copper	Oxygen about 0.04%	0.323	1980	17.7×10^{-6}	101%	0.94
Oxygen-free copper	Substantially pure copper	0.323	1980	17.7×10^{-6}	101%	0.94
High conductivity phosphorized copper	Phosphorus about 0.007%	0.323	1980	17.7×10^{-6}	101%	0.94
Low conductivity phosphorized copper	Phosphorus about 0.02%	0.323	1980	17.7×10^{-6}	80 to 90%	0.77 to 0.85
Arsenical copper	Arsenic about 0.25%	0.323	1980	17.7×10^{-6}	45 to 80%	0.46 to 0.73
Tellurium copper						
Type A	Tellurium about 0.5%	0.323	1980	18×10^{-6}	98%	0.92
Type B (hardened)	Tellurium 0.5%, nickel 1.0%, phosphorus 0.2%	0.323	1900	18×10^{-6}	60%	0.62

Fabrication Properties

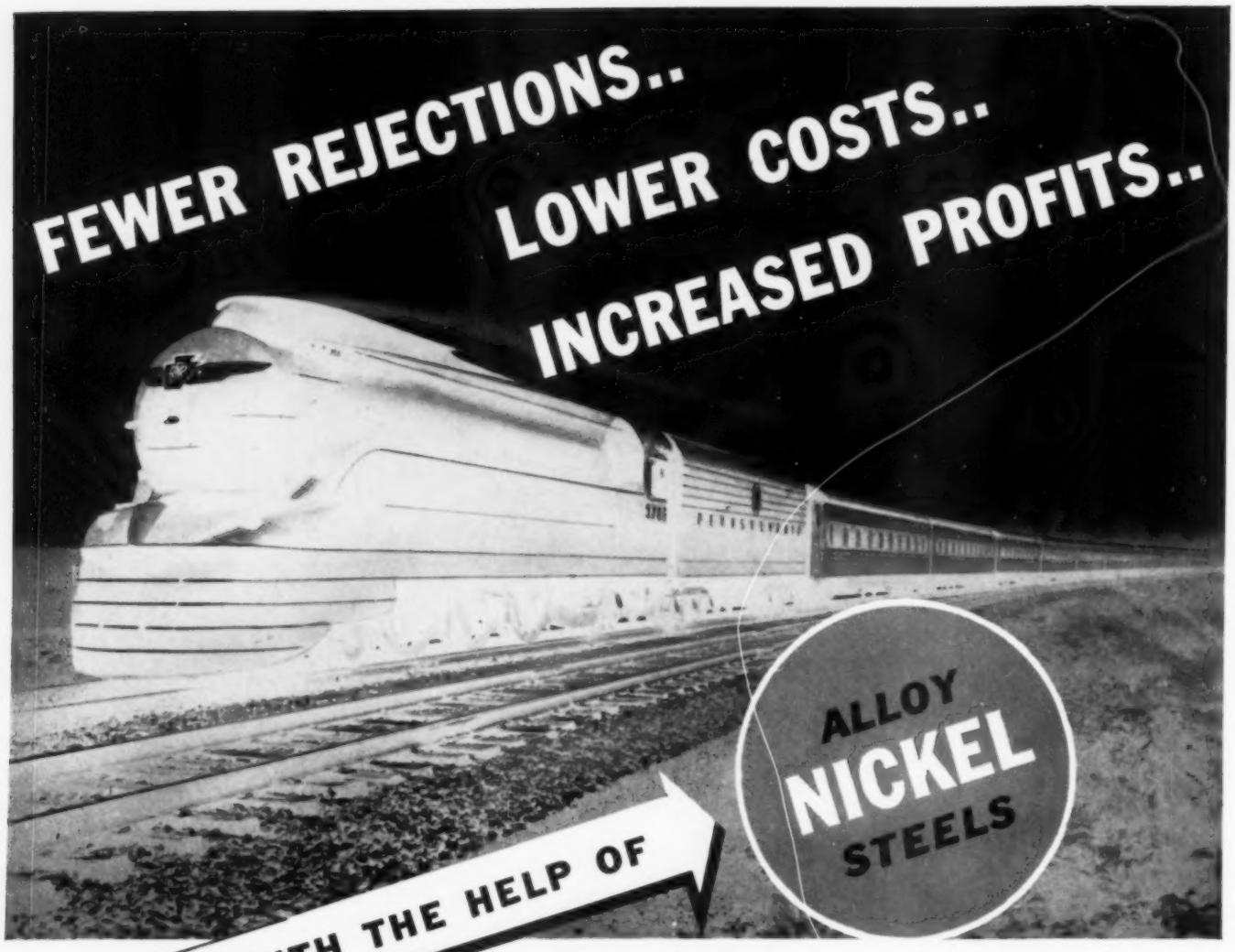
Name	Approximate Relative Suitability for Being Worked		Best Temperature for Hot Working; °F.	Approximate Relative Suitability for Being Welded				Approximate Relative Machinability	
	Cold	Hot		Gas	Carbon Arc	Metal Arc	Resistance	Rating*	Type Chip
Electrolytic tough pitch copper	Excellent	Excellent	1400-1600	Poor	Fair	Good	Poor	20	Long
Oxygen-free copper	Excellent	Excellent	1400-1600	Fair	Good	Good	Poor	20	Long
High conductivity phosphorized copper	Excellent	Excellent	1400-1600	Fair	Good	Good	Poor	20	Long
Low conductivity phosphorized copper	Excellent	Excellent	1400-1600	Fair	Good	Good	Poor	20	Long
Arsenical copper	Excellent	Excellent	1400-1600	Fair	Good	Good	Fair	20	Long
Tellurium copper									
Type A	Excellent	Excellent	1400-1600	Fair	Fair	Fair	Poor	100	Short
Type B	Excellent	Excellent	1400-1600	Fair	Fair	Fair	Fair	100	Short

*Free cutting brass = 100.

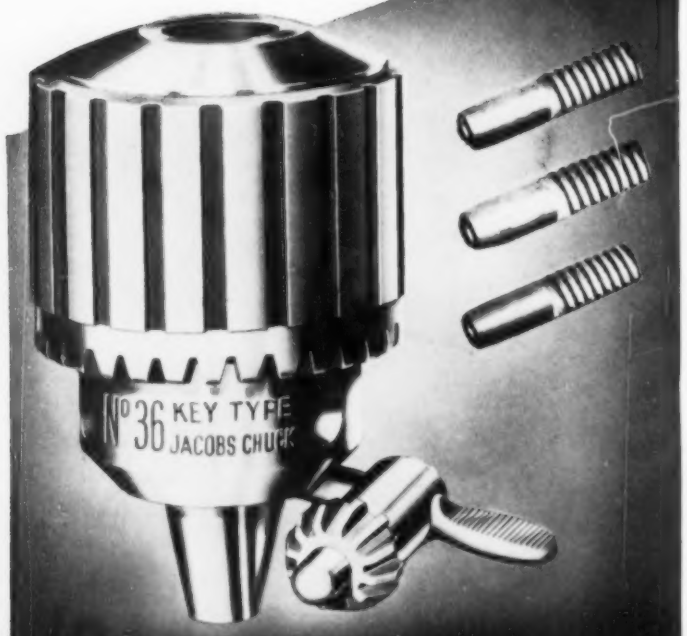
Average Hardness and Tensile Properties of the Seven Types of Copper

Figures are average and not to be used for specification purposes.

Section Grain Size or Temper Heat Treatment	Rockwell Hardness		Tensile Strength; Psi.	Yield Strength at ½% Elongation Under Stress; Psi.	Elongation in 2 In.; %	Shear Strength; Psi.
	F	B				
0.040-in. sheet; 0.015 mm.; anneal	45	..	35,000	10,000	40	24,000
0.040-in. sheet; 0.030 mm.; anneal	40	..	32,000	10,000	45	23,000
0.040-in. sheet; hard	90	..	51,000	45,000	10	28,000
0.040-in. sheet; spring	95	..	57,000	53,000	6	29,000
1 x 0.049-in. tube; 0.030 mm.; anneal	40	..	32,000	10,000	45	23,000
1 x 0.049-in. tube; hard	90	..	50,000	45,000	12	28,000
No. 12 B.&S. wire (0.081 in.); 0.030 mm.; anneal	..	..	32,000	10,000	..	24,000
No. 12 B.&S. wire; hard	..	..	60,000	55,000	..	30,000
1-in. rod; hard	..	..	40,000	.....	30	25,000
1-in. rod; hard (Type B tellurium copper only)	..	76	70,000	47,000	18	45,000



..WITH THE HELP OF



MODERNISM **brings new customers and new profits to railroads. Typical is the "Broadway Limited," leader of the Pennsylvania's fleet of nine new streamliners. From car truck frames of Nickel alloy cast steel to Nickel-copper-molybdenum steel roofs, Nickel saves weight, lengthens service life and pushes down cost per mile and cost per year.**

WHETHER you're hauling extra fare passengers, or doing precision machining—Nickel can make each ounce, each inch of metal do more work at lower cost per year.

Nickel, alloyed into steels, irons or non-ferrous metals, provides improved mechanical properties. The heightened abilities of Nickel alloyed materials cut rejects during production, lower machining costs, and increase profits by lengthening service life. For specific information about money-saving applications of Nickel in your industry, please address your inquiry to the address below.

REJECTIONS CUT 75% **—"Since using Nickel steel (SAE 4615) rejects due to warpage in heat treatment have dropped 75%," says Jacobs Mfg., Co., Hartford. "This Nickel-molybdenum steel provides required hardness and toughness in drill chuck jaws, plus added core strength to prevent bending or breaking. Nickel alloyed chucks *stay* accurate—assure accurate boring and machining."**

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL ST., NEW YORK, N.Y.

Failure of Press Tools

under fatigue and impact

Courtesy Timken Roller Bearing Co.

By C. E. Bretney *

QUITE OFTEN, the production manager or foreman of a metal-working plant is confronted by a machine operator with a broken die or punch or tool of some sort; almost invariably the explanation of the accident is "It just broke, I don't know why". In many cases, the true cause of breakage is beyond the operator's knowledge and responsibility. In fact, there is a surprising lack of knowledge even among tool designers, toolroom supervisors, heat treaters, and set-up men about the many apparently small details which have a large effect on the operating efficiency of machines, the life of the tools and the quality of the product.

It is therefore worth while to preach a little sermon to the text "More attention should be given to small details", especially as these affect the fatigue strength and the impact strength of the tools.

As should be well known, the fatigue strength, or the endurance limit, is that stress below which a material will withstand an indefinite number of cycles of stress without failure. No attempt will be made to analyze the mechanism of fatigue failure, for that has been done elsewhere by far more competent persons; however, attention should be called to the fact that laboratory experiments to determine the endurance limit are made on specimens whose surface is shaped and smoothed with extraordinary care. This is necessary, else the results will be very erratic. In other words, a slight irregularity in shape or smoothness will increase the theoretical stress at that point, and cause premature failure.

One might almost expect that careful tool designers and tool makers would therefore take the greatest care to avoid these notches, scratches, machine tool marks and sharp corners. Since unfortunately they do not, it is well to cite some laboratory experiments determining their actual effects. R. Cazaud reported in *Revue de Métallurgie* in 1936 that fatigue strength can be reduced as much as 40% by cutting a circular groove 0.003 in. deep around a ¼-in. soft steel rod. R. Mailaender in the Krupp Laboratories observed that the fatigue strength of a steel can be reduced as much as 80% by notches, the actual percentage being dependent on the radius at the bottom of the notch and the hardness of the steel. W. N. Thomas states that fatigue strength of a polished specimen was reduced anywhere from 2 to 20% by machining marks, depending on the process; heavy filing

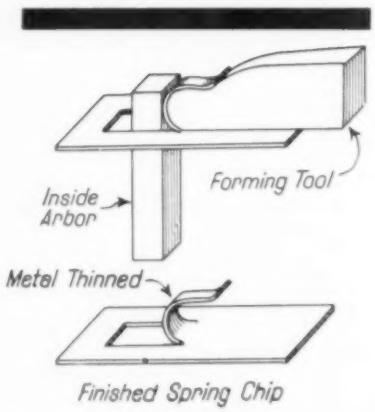
*Tinnerman Stove and Range Co., Speed-Nut Division, Cleveland

reduces it as much as 18 to 20%; fine emery polishing 2 to 3%.

Of all mechanisms, springs are the best examples of parts which must have an endurance limit well above their working loads. That so many springs break is due not so much to inferior metal as to the damage done them by scratches from improper forming tools, rough oxidized surfaces from heat treatment, or corrosion in service. All these are efficient stress raisers, or cause notches that are efficient stress raisers, bringing the actual loads at a critical point considerably above the endurance limit of the metal.

Researchers at the National Physical Laboratory in England have studied the effect of surface conditions on the fatigue strength of springs. The results of this work show that surface irregularities produced by manufacturing operations may reduce the actual endurance limit (not of the metal but of the spring) by one quarter to one half of that to be expected on the basis of tests on finely machined and ground specimens. Tests made by Lea and Heywood on chrome-vanadium valve spring wire showed that the torsional endurance limits increased almost twice after machining and polishing the wire. Results obtained by Hankins and Ford showed that a decarburized surface layer left there by heat treatment reduced the endurance limit of silicon-manganese steel from 107,000 to 60,000 psi. The writer has seen examples of flat steel springs reduced approximately 50% in fatigue strength by tool marks only 0.001 to 0.002 in. deep.

Doubtless the last statement should be modified by saying that at the region where the tool marks occurred there was also enough cold work to thin the material slightly. The circumstances are as shown in the accompanying sketch. In this tool set-up there was inadequate clearance between the forming tool and the inside post or arbor. The strip being bent to a required shape is a 0.70% carbon steel, formed in the annealed state, and heat treated subsequently to spring temper. This stretching of the material has the same weakening effect as a sharp notch, and is often overlooked as a cause of failure. (Sometimes blame has been placed upon both heat treatment and such finishing treatments as electroplating.) Thinned spots of this sort may be more susceptible to embrittlement by hydrogen from a cleaning or plating tank, and therefore are further weakened at the already "unhealthy" region.



If There Is Insufficient Clearance Between Inside Arbor and Forming Tool, and the Metal Is Squeezed and Thinned a Little, This Spot Will Locate Many Fatigue Cracks Later

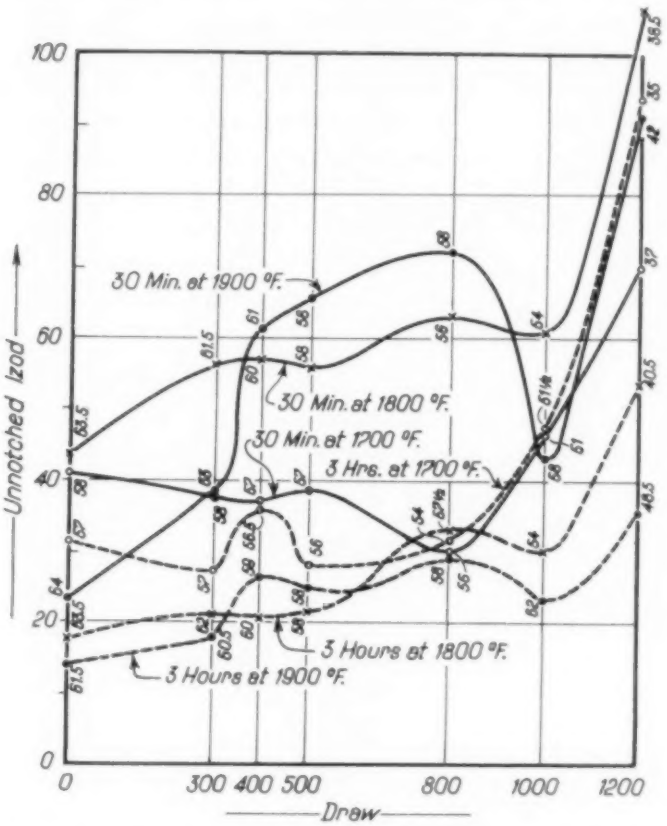
It may be pointed out that designers are well acquainted with the above facts. Engine valve springs, aircraft propellers, axles, and many other high duty machine parts are examined carefully, even under a magnifying glass, to make sure there are no damaging marks. Likewise the notation "Must be free from tool marks and scratches" is quite common on prints for parts subject to stress. But a somewhat familiar knowledge of the habits of tool and die makers, machine operators and inspectors leads the writer to state that little attention is paid to such notations. This is said with no thought of questioning the ability or honesty of these men. The accusation to be made is that they are not aware of the *importance* of such small marks, scratches and notches as a source of trouble.

Factors Affecting the Impact Strength

A true impact failure may be defined as instantaneous rupture without plastic distortion under instantaneously applied stress. These are ideal conditions. In practice, when the load is not applied instantaneously and some plastic distortion takes place, the failure results from some combination of tensile or compressive and shear stresses. "Toughness" is resistance to such a complex system of stresses. Obviously, then, the present Charpy and Izod impact tests cannot be correctly described as tests of toughness.

More than any other property, the toughness of steel is probably affected more by changes in the distribution and composition of the micro-constituents — that is to say, its heat treatment. For instance, see the curve sheet reprinted on the next page, setting forth data by W. H. Wills ("Further Study of a

High Carbon, High Chromium Tool Steel", *Transactions*, Vol. 25, p. 1013). Chemical analysis of the steel he used was: 1.56% carbon, 11.48% chromium, 0.24% vanadium and 0.76% molybdenum. This is an air hardening steel, and all samples were cooled in still air. Some were heated 30 min. in an open fire at 1700, 1800 and 1900° F. Others were 3 hr. at the same temperatures but packed in spent charcoal to minimize surface changes. Pieces were then drawn and tested in quadruplicate.



Relation Between Izod Unnotched Impact Values and Rockwell C Hardness After Various Heat Treatments. 1.5% C, 11.5% Cr steel. (After Wills)

Note that the impact values very generally are considerably higher for pieces quenched after a short heating than after a long heating; the impact values for the 30-min. samples also interchange in a rather unpredictable way. Quenching temperature also seems to have a minor effect on impact values (except on very high draws) if the samples are a long time at heat, but the combination of long time and high temperature before quench causes erratic results — that is, the test figures have a wide spread from maximum to minimum.

Ratio of impact value to hardness is important. Given a good working hardness, a high value of this ratio (near unity) is had on this steel at all draws between 200 and 1000° F. after cooling from 1800° F. (30 min.). Even higher ratios are had after cooling from 30 min. at 1900 and drawing at 600 to 800° F., but such a high heat is likely to coarsen the grain and give erratic and low impact tests.

These variations, as shown by Wills for a high chromium steel, do not hold for steels of other compositions. To prove this point the following torsion impact values have been published by Bethlehem Steel Co.:

Condition	High Carbon, High Chromium	Plain Carbon	High Speed
As quenched	..	24	40
Drawn at 300° F.	..	125	..
500° F.	..	55	50
600° F.	..	50	..
700° F.	..	..	35
800° F.	55	75	..
850° F.	..	..	90
900° F.	48	..	..
950° F.	45	..	..
1000° F.	48	..	30

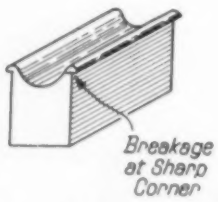
However, the impact values of heat treated alloy steels are definitely related to the drawing temperature and, of course, the hardness values. The high impact value of the plain carbon steel after a 300° F. draw results from the extreme hardness, and a steel so heat treated could not be expected to stand a great bending strain. A high speed steel with the lower impact values after drawing to say 700° F. would have no great practical application. However, a plain carbon steel tool drawn at 700° F. would have wider uses even with the lowered impact values, than if drawn at 300° F. with high impact.

The application of the tool decides the tempering temperature. If a sacrifice of either property, hardness or impact strength, is to be made, the use of the tool decides which shall be given the controlling consideration. Isolated cases have been seen in which an exceedingly low drawing temperature of approximately 275° F. has been successfully used in alloy toolsteels.

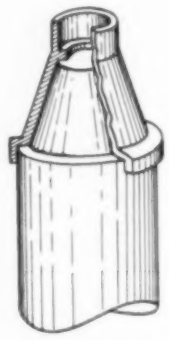
Before leaving this complex subject of the relationship between composition, heat treatment, toughness, hardness and utility, it may be remarked that toolsteels of the same general type, but with a variation in some alloying element, show distinct characteristics which, if known, may be put to advantage in certain applications. On the other hand, known characteristics may prohibit their use for another type of tool. To cite an example of two well-known brands of high carbon, high chromium, air hardening toolsteel, one contains an addition of about 0.80% molybdenum. This steel shows

excellent "toughness", even though the air hardening steels are generally understood to be not very remarkable in that respect. The other brand, in addition to the usual carbon-chromium content, contains 1% tungsten. Tools from this analysis show remarkable cutting ability, outwearing the first-mentioned by a large amount when used, for instance, as a press blanking tool. In contrast, its "toughness" is low and it is unwise to use it in an application which includes a bending strain.

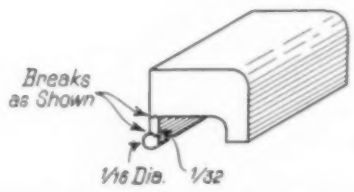
Many level-headed metallurgists believe that, in the case of a tool failure, a change of steel will not necessarily eliminate the trouble. Undoubtedly, the first consideration should be to eliminate the stress concentration. But this is not always possible, and the writer has had many experiences in which a change of steel entirely cured a serious difficulty, although the recognized stress concentration remained.



Inside Forming Arbor That Has Serious Stress Concentration at Corners Under Lip. Since it was impossible to change the design it is necessary to make the part of a steel with high strength, high impact resistancee and fatigue resistance



Round Tool for Cold Header. Cracks from the corner wreck carbon steel tool in about 20,000 operations. Cr-Ni steel tripled the life



High Speed Steel, Drawn at 900° F. for High Impact Strength, Produced a Blanking Die That Was Practically Indestructible, Notwithstanding the Very Frail Section

The left figure on this page shows an inside forming arbor used in a bending fixture for a punch press. Pressure causes a stress concentration at the sharp corners under the lip, and the requirements of the part made it impossible to alter the shape of the tool in any manner which would relieve the condition. Plain carbon toolsteel and manganese oil hardening toolsteel were tried without success. High speed steel was eventually tried with very gratifying results.

A similar case is shown in the right-hand sketch. This is a blanking punch with a rather unusual section, due to the frail $\frac{1}{32}$-in. section. For the first set of press dies made, an air hardening (high carbon, high chromium) toolsteel was specified. These punches cracked in heat treating. Oil hardening manganese toolsteel was then tried; these punches stood six or eight strokes of the press before they cracked. High speed steel was used next. The results were very unusual, for the punches produced millions of blanks and never were replaced, notwithstanding many hard strains put on them by operating inaccuracies in other stations of the die. The drawing temperature used on these punches was 900° F. (Reference to the data given above for different drawing temperatures of high speed steel will show that this temperature produces a high impact value.)

However, a wholesale substitution of high speed steel in blanking dies is not advisable. Considerable care must be taken in fitting punches to dies of this steel, especially if the metal being blanked is fairly thin. Such close fitting is difficult because high speed steel usually shrinks, scales, or otherwise loses 0.002 to 0.003 in. on a part about $\frac{3}{4}$ in. square. The best heat treating practices will, of course, minimize this loss. Whenever the finished tool can be ground to size, there is no cause for concern, but in die work very little grinding is possible on contours of blanking parts.

A cold heading bumper tool is shown in the central sketch. When made of plain carbon toolsteel they averaged 20,000 pieces per tool. This is a circular tool and the breakage occurred at the point where the angle of the nose adjoined the straight portion of larger diameter. As an experiment to reduce replacement costs, a chromium-nickel steel was tried and these tools averaged 60,000 pieces before breakage occurred — just triple the previous production using plain carbon toolsteel.

Critical Points

by the Editor

TO Plainfield and New Brunswick in New Jersey, with GEORGE STRAHAN of International Nickel Co.'s publicity department to see how a truck engine is built. A. H. SANDFORD, assistant chief inspector for Mack Mfg. Corp., guided us through the maze of machinery, and dispelled any idea that a 5-ton truck engine is a rough and ready machine. It's tough enough, but able to stand up to heavy service because of high quality and precision in all its parts. Cylinder block castings, for instance, get a 12-hr. stress relief so they will hold their accuracy; cylinder bores, after finish machining, are honed to remove the last 0.001 in.; piston pins are ground and lapped until the surface viewed at 50 diameters appears dull under diffuse light rather than reflecting brightly from the micro concavities of tiny polishing scratches. Diesel engines have a nickel cast iron sleeve pressed in for long wear and all blocks for gasoline or diesel engines have stellited valve seat inserts — rings of low expansion, 40% nickel-iron alloy, ground to shape, refrigerated, and driven home in the warm block. Reminiscent of practices observed 20 years ago at Rolls-Royce, each engine gets a 3½-hr. test on the block, whereupon it is dismantled, inspected, rebuilt, and given a final 3½-hr. run before being released to the assembly line.

accuracy a fetich of truck makers

At a rather large luncheon, expressed the idea that our own Army but especially the Navy department would do well to take the editors of engineering magazines somewhat into their confidence. There is rarely any non-military discussion of the thousands of engineering questions that must constantly be arising in this day of mechanized battle. Certainly these problems are not being solved with the ease and certainty that admits of no help or criticism. If the road builders, the aircraft designers, and the steel makers profit from free discussion of their current problems in the technical press, military engineers should likewise benefit. A parallel may be drawn between the ignorance of American engineers concerning the techniques of naval defense and the vacuum of international news enveloping Italians, Germans and Russians. In contrast, the responsible British engineering magazines frequently discuss (even today) such things as U-boat defense, speed and maneuverability of aircraft, fuel supply for motorized equipment — discussions that must have been written against a generous background of accurate information about current conditions in the land, sea and air forces.

censorship of military information

At that same gathering Col. GLEN F. JENKS, of the Army ordnance department and an expert on heavy artillery, expressed the opinion that "snowflake", that dread scourge infecting such a large percentage of gun tubes manufactured by war babies during World War I, is something that is controllable and need not now become a cause of rejections. While commander at Watertown Arsenal he detailed GRATIAN YATSEVITCH of the research staff to study the ingot, forge and heat treating practice of the four American firms which have had long experience and great success in gun manufacture. In some ten years' study a body of safe practices was recorded and systematized and is now available to American firms who contract for gun forgings either in quantity or on "educational orders". That they are effective is proven by the experience of Camden Forge which used them and has had no trouble — whereas an equally competent organization, which went ahead on its own, had several rejections from flakes.

flakes in gun tubes controlled

Over at the plant of W. S. Tyler Co., Cleveland manufacturers of wire cloth (among

other beautiful things), to see how GEORGE KUHN, metallographer, polishes without wheels or emery cloth. HUGH BROWN, director of research, said they have merely adapted old methods — see, for instance, the note on p. 771. Nevertheless KUHN is now able to report back to the wire mill a grain size determination within 60 sec. (yes, seconds), and since fabrication of non-ferrous wire of standard analyses is controlled by micro grain size rather than tensile or elongation tests, one can easily see what a prompt report means to the operator of a continuous annealer. To be as brief as the method: Fine wire is wrapped tightly around a small bakelite cube; coarser wire is bent for a good plier-hold. Three or four strokes on a mill file flatten the sample, it is grasped with tweezers wired to the positive pole and immersed just below the surface of the polishing solution in a shallow beaker. The solutions vary, but one part of nitric acid in two parts of alcohol will do for most alloys. A strip of stainless steel cloth acts as cathode for pulsating direct current rectified from 60-cycle alternating current in a battery charging set, and transformed to about 60 volts. In 10 sec. the file mark ridges slough off and the surface is scratch-free and flat enough to photograph at 250 diameters. Etching to bring out grain boundaries then proceeds merely by twirling a rheostat knob and reducing the imposed voltage to near zero. A quick alcohol wash, a warm air blast, and the sample is ready for the microscope. Presto!

speedy polishing without abrasives

Herewith is placed on record a personal snort of disdain for the manufacturer of a $115 gas range (retail price) who puts in a common steel spring to shut the oven door, which spring corrodes in the condensate collecting below the insulated walls, lets go, and then costs the owner $5.22 in mechanic's labor to dismantle the stove to a point where it can be replaced with a non-corrodible spring costing 70¢ (retail price). A friend with a passion for anonymity, but even so a maker of good springs, writes that the material in these springs costs 1.2¢ each for hard drawn spring wire of carbon steel, which rusts and which loses strength at 250° F. Chrome-vanadium steel wire resists heat better (at least to 400° F.) and costs 6.6¢, but will also rust. Enough inconel for this spring costs 14.5¢; it can operate under a fiber stress of 50,000 psi. at 700° F. and doesn't rust. It oughtn't to cost much more to make and install an inconel spring than a carbon steel spring (other than the raw material), yet the stove manufacturer pinches 13.3¢ out of his stove and the customer later spends nearly $6.00 to keep the oven door closed — a minor matter but really necessary if the festive turkey is to attain a proper brown!

costs $5.92 to save 13c

Opined that test engineers, many of them ASMembers, will have a new outlook on life after reading WALTER DAVENPORT's "The Car Killers" (*Colliers* for Oct. 28). His main thesis, which we endorse, is that traffic accidents are due to the driver and not to the car, and he proves it by a sprightly account of a visit to the research laboratories and proving grounds "wherein metallurgists, chemists, physicists and other scientific persons pursue a dissatisfied life . . . . a dour crowd who spend their time sneering at their own work." [Who's afraid of the big bad wolf?] Mr. DAVENPORT describes the laboratories as "a sort of BILLY ROSE carnival of scientific whoopee", about as accurate, even after making allowance for journalistic jargon, as his finding an ELEANOR HOLM in ". . . . the diffraction X-ray device, the idol of engineers . . . . a sort of lie detector that noiselessly bombards metals with atoms" or "the magnaflux apparatus, wherein the bar is dusted with iron powder; delicate magnets are lowered, and quickly all surface iron powder is drawn off, leaving only the small quantity that has fallen into a crack no microscope has been able to show up". Is it only an accident, or is it a sign of progress in non-technical technology, that no mention was made of the crystallization of metals in fatigue?

some non-technical technology

Some current definitions among non-technical papers in mid-year examinations:

Conundrium — A rare metal from the mines in the Acrostic region.

Barium — What they do to dead people.

Electrolyte — A thing which when it is dark you turn on and it gets bright.

Silicon — A tipsy jailbird.

Chlorine — A dancer in a night club.

Boron — A nit-wit.

Correspondence

and foreign letters

"Troostite" or "Fine Pearlite"

Special Letter to METAL PROGRESS
By O. A. TESCHE
Metallurgical Physicist
Randfontein Estates Gold Mining Co., Ltd.

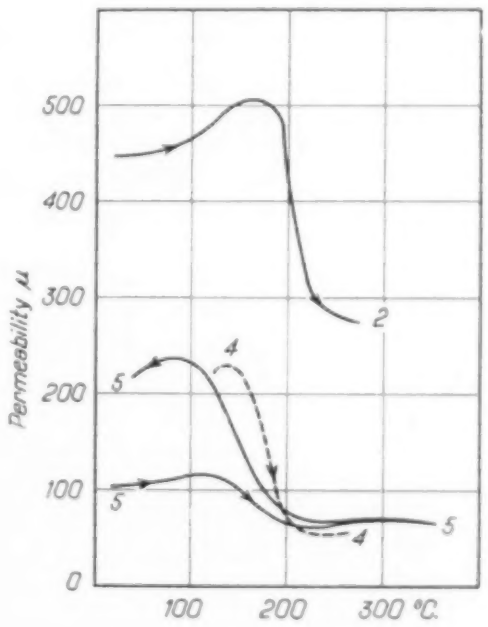
RANDFONTEIN, TRANSVAAL — The observations communicated under the above heading in the March issue of METAL PROGRESS have been continued during the past few months. I found it desirable to revise the testing method. The dimensions of the test ring were left unaltered, but the primary coil around one portion of this ring is now connected to either a source of direct current for magnetizing, or an alternating current for de-magnetizing. The secondary coil is connected to a Grassot fluxmeter, indicating Maxwell turns. The primary direct current used in these later experiments was such as to create a uniform magnetic field of 20 c.g.s. units within the ring. By a simple calculation the indications of the fluxmeter can be transformed into figures for the magnetic permeability.

The experiments made were simply this: The ring to be observed was placed in a furnace and slowly heated or cooled. Prior to taking a magnetic reading, the ring was de-magnetized, then the direct current was switched on, the fluxmeter reading recorded, and the permeability calculated and plotted against the temperature at the time. The structural states of the 1.05% carbon steel remeasured by this method were No. 2, 4 and 5 of the previous letter.

The accompanying graph shows the results obtained. In No. 2 (furnace cooled) the height of "cementite wave" is 222 and the magnetic residue is 276 (in units of permeability).

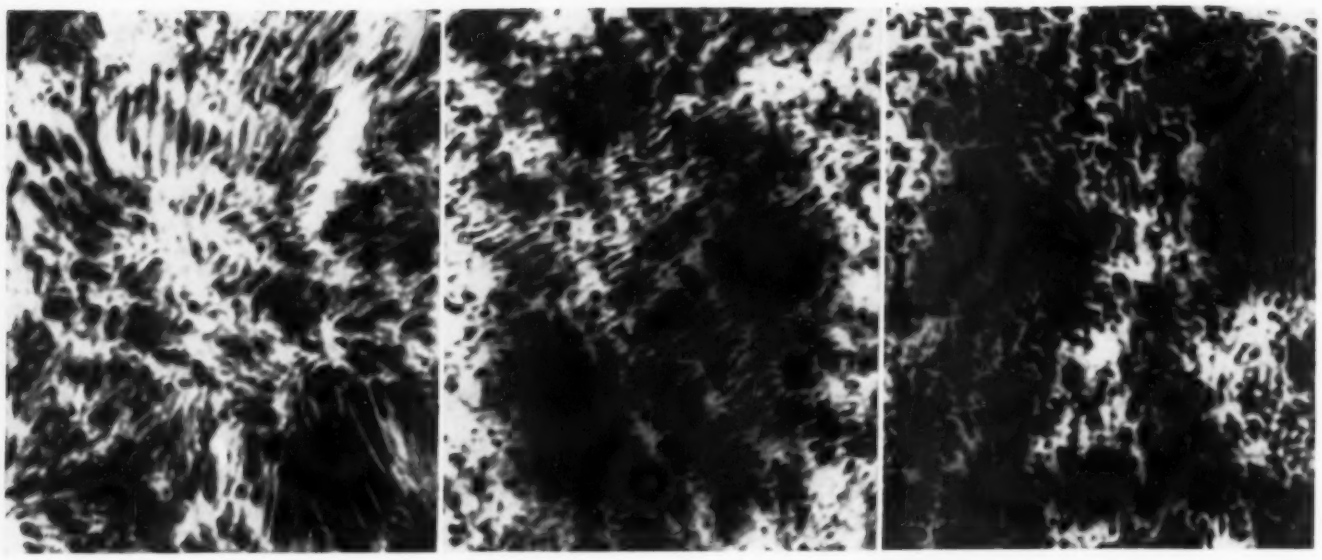
No. 4 (air quenched): Height of cementite wave is 173; magnetic residue is 58.

No. 5: The oil quenched steel shows a large difference between "up" and "down" curves, obviously due to a structural change which I think is the breaking down of residual austenite during the heating cycle (up to 354° C. or 670° F.). The height of the cementite wave on the "down" curve is 170 and the magnetic residue is 68. The cementite wave in this case shows a remarkably large lateral spread — that is, the changes start at about 240° C. (450° F.) and continue down to 90° C. (190° F.).



Changes in Permeability of Ring Magnets of High Carbon Steel on Mild Reheating. No. 2 had been furnace cooled, No. 4 quenched in an air blast and No. 5 in oil

Possibly the differences observed in the magnetic residue between slowly cooled and rapidly cooled samples are caused by differences in the thickness of the ferrite lamellae; there is some evidence in the physical literature that thin films of iron are magnetically hard — simply because they are thin. However this may be, the fact remains that the cementite wave is a physical property often highly sensitive to variations in structure.



Negative Views (Cementite Light) of 1.05% Carbon Steel at 5000 Diameters. Left is normalized structure, center is brine quenched and tempered at 750° F., right is austempered at 750° F.

I also made a few observations on the electrical resistance of samples at room temperature and after the various heat treatments and I obtained the following results:

1. As from factory (Rockwell B-96): 1.83×10^{-5} ohms.

2. Heated for 35 min. at 900° C. (1650° F.) and cooled in the muffle (Rockwell C-14): 2:00.

4. Heated as under 2, but cooled in compressed air (Rockwell C-34): 1.97.

5. Heated as under 2, but quenched in oil (Rockwell C-47): 3.44.

5a. Heated as under 5, and then heated for 30 min. at 400° C. (750° F.): 2.05.

6. Heated as under 2, but quenched in brine (Rockwell C-61): 4.11.

7. Treated as under 6, and tempered for half an hour at 400° C. (750° F.) (Rockwell C-45): 2.04.

8. Heated for 35 min. at 900° C. (1650° F.) and austempered at 400° C. (750° F.) in molten lead for half an hour (Rockwell C-49): 2.05×10^{-5} ohms.

The results from No. 2, 4, 5a, 7 and 8 are all very similar, tending to show that the separation into cementite and ferrite must be quite complete when the sample is cooled in cold oil or more slowly, or when the more rapidly quenched samples are re-heated to 750° F. Apart from this useful finding it is, however, recognized that the electrical resistance is not at all a "structure-sensitive" property; the distribution of cementite and ferrite has almost no influence on it. (The coarsely spheroidized state No. 1 as received from the mill is an exception to this rule.)

Finally, I made another, more direct attempt to throw light on the nature of the iron carbide distribution in "pearlite", "sorbite", and the other structures. An examination of my original photographs, reproduced in the former letter (March 1939, pages 274 and 275), showed that many areas of these would stand further magnification. The special technique I devised for this purpose was as follows: Diapositive plates were prepared from the original negatives and then projected, with a magnification of 2¾ diameters, onto gaslight paper. These prints, now all at 4000 diameters magnification, are really negatives of the original structures; as tests have shown, however, this is a decided advantage in revealing the details of the cementite distribution. The cementite lamellae or globules appear in a light color on a dark background.

The best picture was obtained from the air cooled (normalized) sample No. 3; it shows that in this area at least the cementite has left the rigid order of pearlite and has assumed a cellular design. (It must, however, be said that this is not the general rule.) Likewise, in the oil quenched sample (No. 5) the cementite, although perhaps lamellar, attains a greater freedom of form than in well-defined pearlite. Of special interest is also the austempered sample (No. 8); the cementite has acquired an unusual form.

Again I draw attention to the occurrence of lamellar elements in the brine quenched and tempered sample (No. 7, the central one in the group reproduced). This phenomenon is contrary to the usual concepts; but I may mention that I found lamellar elements in the original

photograph of the brine quenched sample; it may have originated by the cooling curve (temperature vs. time) crossing for a short distance the "nose" of the Bain-Davenport S curve. It is possible that, on tempering, iron carbide crystallized onto these faint lamellae, bringing them out more clearly in the tempered sample.

O. A. Tesche

Endurance of Valve Springs

Special Letter to Metal Progress
By Alberto Oreffice
Chief Engineer, Steel Department of the Fiat Co.

Turin, Italy — In the March issue (1939) of Metal Progress was published a brief note telling of our success in appraising the excellence of valve-spring wire by its ultimate tensile strength and the number of alternate 180° torsions it would endure before fracture. This note contained minimum values we now specify for such wire of various diameters, values which if exceeded we have found to correspond with satisfactory life in service.

This additional note is to show that high endurance limit in hard drawn, quenched and tempered carbon steel wire is associated with a high number of alternate 180° torsions, as well as a high ultimate tensile stress. Some authorities maintain, mistakenly, that there is a definite relationship between ultimate strength in torsion and the endurance limit. This does not always hold true, as shown in the adjoining table which gives the results on two different spring-steel wires 4½-mm. (0.177-in.) diameter.

It will be noted that all test values are within the same range of magnitude except the alternate 180° torsions and the endurance limits (established for axial stress between no load and maximum in tension). The first steel will withstand on the order of 170 alternate torsions and its endurance limit is 0-55,000 psi. The second steel, which has proven itself to be a very fine steel for valve springs, will withstand more than twice the number of alternate torsions (390 average) and its endurance limit is raised to about 0-84,000 psi.

Alberto Oreffice

Valve Spring Wire With High Endurance

Temper	Tensile Tests			Torsion Tests		Alternate 180° Torsions	Endurance Limit
	Yield	Ultimate	Elonga.	Yield	Ultimate		
0.96% C, 0.62% Mn, 0.19% Si, 0.037% P, tr S							
As received	214,800	248,000	1.5%	102,400	190,600	152	51,190
464° F.	239,000	264,500	3	118,000	190,600	163	51,190
536	223,200	260,200	3.5	113,800	190,600	170	51,190
608	210,500	253,000	4.5	95,300	190,600	145	62,600
680	202,000	247,500	5	91,000	184,900	221	57,590
0.68% C, 0.56% Mn, 0.23% Si, 0.035% P, tr S							
As received	204,800	241,700	3.5%	78,300	182,000	370	85,320
464° F.	240,300	258,800	2.5	139,400	192,000	360	81,100
536	231,800	251,700	4	139,400	189,100	400	81,100
608	223,200	243,200	5	139,400	189,100	350	89,600
680	202,000	234,600	6	135,000	192,000	485	82,600

Lining a Small Induction Furnace

Special Letter to Metal Progress
By George F. Comstock
Metallurgist, The Titanium Alloy Mfg. Co.

Niagara Falls, N. Y. — In Mr. Austin's discussion of special refractories, at the top of page 654 in November Metal Progress I noticed that magnesia is stated to be a suitable material for ramming around clay-bonded magnesia crucibles in small induction furnaces. That method was used by us, but it gave such frequent and serious trouble that we soon gave it up, and tried zircon instead of the magnesia. This was found much more satisfactory since it does not shrink. The zircon does not normally get hot enough to react with the basic crucible, and no trouble of that kind has ever been encountered.

Our experience with clay-bonded magnesia crucibles is that they invariably crack in cooling after the first melt. When packed in a shrinking material like magnesia the steel penetrating the cracks in the crucible is very apt to find a passage through to the coil, thus preventing further operation, but with the non-shrinking zircon packing the crucible cracks do not matter. The zircon should be a dry uniform mixture of 85% granular and 15% milled. Warming the crucibles slowly, as recommended by the maker, each time the furnace is started up from room temperature has been found to be a

useful precaution; we accomplish this by arranging a lighted 100-watt electric light bulb inside the crucible during the night before we intend to operate.

Possibly some of your readers might be interested in another method for making magnesia linings for steel melting in small induction furnaces, which we have used successfully, but which is not mentioned in the article referred to. This method involves sintering the dry lining material in place by means of graphite plugs which are heated inductively. One plug should be made as large as the outside of the magnesia crucible which otherwise would be used; this is for sintering the zircon. Another graphite plug the same size as the inside of the crucible is required for sintering the magnesia lining. Both should be slightly tapered, have small vent holes drilled from top to bottom, and a threaded cavity at the top for a bar for removing the plug while it is still hot. Any absorbed carbon (or reducing effect) is then removed from the sintered zircon by exposure to air while it is still red hot, thus preserving its full insulating value. The vent hole is necessary to prevent gas pressure from lifting the plug out of the furnace during the sintering process.

This method is applied to a 17-lb. furnace in the following way: After packing the bottom of the furnace firmly with the dry 85-15 zircon mix, the sheet-mica cylinder is inserted and expanded to fit tightly against the coil. The mica should not flake readily when bent, and may be formed conveniently around a glass bottle slightly smaller than the inside of the furnace coil. The furnace bottom is generally built up with zircon somewhat above the base of the mica. Then the larger graphite plug is set in place, and it should have a layer of paper about 0.025 in. thick glued closely around its sides, to burn away during sintering and provide clearance for easy removal afterward. The plug we use is 4½ in. in diameter at the top, 4⅜ in. at the bottom, and 8 in. tall. The dry zircon mix is packed very firmly around it, hammering the rammer at each layer, to insure the tightest possible packing.

Care should be exercised at this point not to tear away any flakes of mica, for if they get in the zircon weak spots or cracks will be formed. One way to avoid this is to protect the inner surface of the mica with a strong paper cylinder while ramming, the paper being raised and torn off at the top after ramming each layer, so that none of it remains behind. Another scheme which we are now using is to have a glass cylinder, 5½ in. outside, $5\frac{3}{16}$ in. inside diameter, 8½ in. tall, to wrap the mica around, and leave it in the furnace while ramming, raising it after each layer so that it does not become fast, and finally removing it from the furnace when the zircon is nearly all rammed in place.

The top of the graphite plug is kept from burning during the sintering operation by a cover of moist carbofrax cement about an inch thick. The best sintering job was done with 15-kw. power for 15 min. and 20 kw. for 25 min. more. The sintering must be sufficient to keep the zircon in place and fairly hard, but should not be continued long enough to carburize it too much. After the 40-min. sintering, the power is shut off, the carbofrax layer removed, and the plug pulled out carefully and buried in a can of graphite chips or dust to prevent burning. The sintered zircon should be open to the air while cooling, to burn off any carbon absorbed from the graphite or paper. After cooling, any slight defects in the inner surface can be patched with zircon cement, using a minimum of inorganic binding agent such as bentonite, and drying finally with the electric light.

For the magnesia lining a mixture of 60% "normag" (electrically sintered MgO through 20 and on 60 mesh) and 40% electrically fused MgO through 200 mesh is rammed on the zircon bottom and around a graphite plug ⅜ in. diameter at the top and 3½ in. at the bottom, and 7½ in. high, coated with paper like the other one. The top of the graphite should be protected with carbofrax as before, and sintering is accomplished with 15 kw. for 20 min., and 19 to 20 kw. for 20 min. more. This plug is removed while hot, and the sintered magnesia allowed to cool while freely exposed to the air. When cold this lining is generally loose from the zircon, since it shrinks in cooling, but this seems to do no harm. Defects can be patched with 200-mesh electrically fused magnesia, or half magnesia and half zirconia, moistened with dilute hydrochloric acid. The top of the furnace is finally shaped with a ring of "normalith", or chrome or mullite cement, which should not be too wet, and is dried with the electric light bulb over night.

Crucibles made in this way have given satisfactory service in melting both low carbon and alloy steels, and the materials required cost very little.

GEORGE F. COMSTOCK.

Collision Testing
(stainless in light weight cars)

Special Letter to METAL PROGRESS
By EDWARD G. BUDD
President, Edward G. Budd Mfg. Co.

PHILADELPHIA, PA. — I have read with interest the editorial in the September issue of METAL PROGRESS telling of the accidents on the Southern Pacific Railroad. In your description of the cars involved in the Tortuga wreck you say they had a side sheathing of stainless steel. These cars were indeed covered with a very thin molding of stainless steel, having the corrugated appearance which with us is standard on our type construction.

This sheathing had nothing to do with the actual strength of the car. It was entirely *appliqué* and was meant to give the train the glistening appearance which we have popularized. With us the appearance is entirely secondary. We use stainless steel because it is very strong and very ductile, and can be relied upon to carry its share of the load. The fact that it is also non-corrosive helps us to get a beauty to the train which cannot be gotten so readily by paint, and a permanency of appearance which paint does not secure at all.

EDWARD G. BUDD

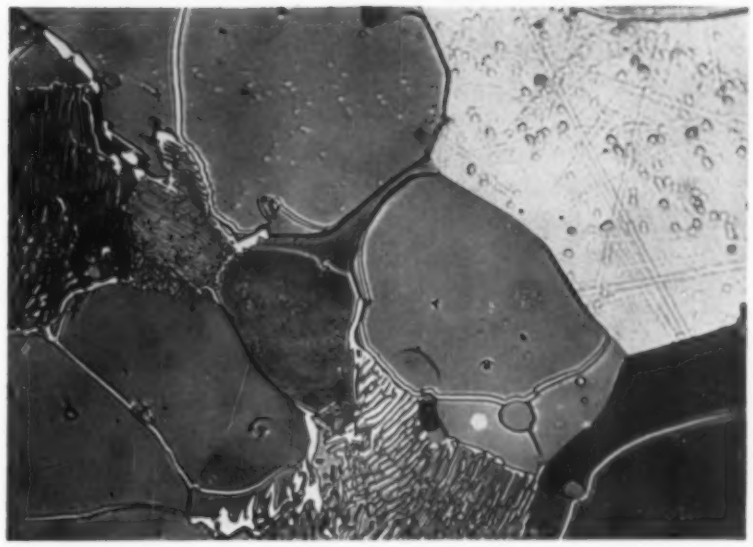


Fig. 1 — Cracks in Colored Films on Ferrite Masquerading as Grain Boundaries. 1000×

Colored Films in Micrography

Special Letter to METAL PROGRESS
By ALBERT PORTEVIN
Professor, Ecole Centrale des Arts et Manufactures

PARIS, FRANCE — The so-called stainless alloys owe their chemical resistance or passivity to the formation of a superficial film, often invisible, that insulates them from the reagent and thus protects the metal from a continuation of the chemical attack. It is, in fact, the chemical attack itself that provides protection by interposing the product of the reaction between the metal and the reagent. This phenomenon may be induced or amplified by means of appropriate additions either to the metal or to the attacking medium.

Oxide films exist naturally, even at room temperature, on the common metals such as aluminum, copper and iron, but they are transparent, only 10 to 100 Ångstrom units thick and consequently invisible. If, however, their thickness is increased either by raising the temperature, by a stronger chemical action or by an electrolytic action, until thicknesses equal to the wave length of visible light are reached, these films cause interference colors. These are usually observed on iron and copper heated in air, producing the temper colors formerly used as an indication of temperature in the tempering of hardened steel.

When still thicker, these films are no longer transparent but assume the color of the oxide. This is scale on steel; sometimes the oxide formed is crystalline, the oxide crystals being oriented regularly upon the grains of the underlying metal by definite relationship between the space lattices of the two materials.

These colored films above mentioned, of

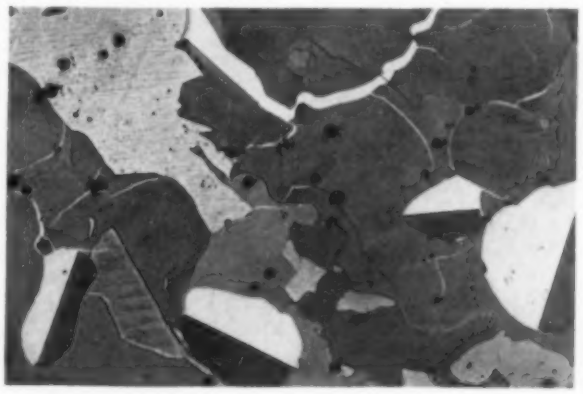
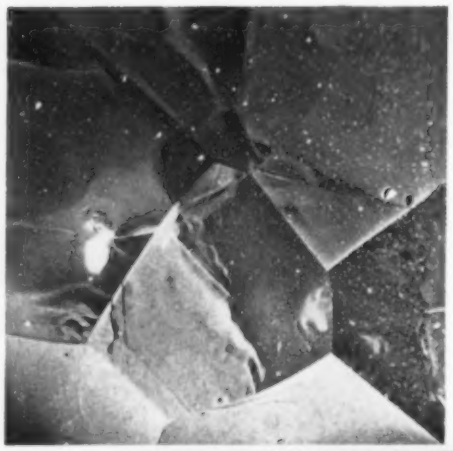
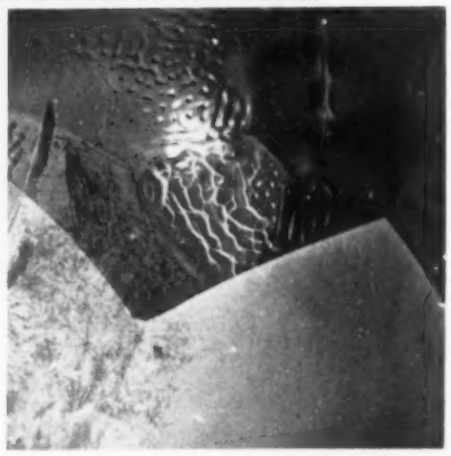


Fig. 2 — Colored Film on Ferrite, Which Has Broken Square Across Two Grains and, Photographing Bright on One Side, Suggests Twinned Crystals. 200×

Fig. 3, above—Equally Spaced and Oriented Cracks in Film Over Austenite Suggest Repetitive Twinning (750×). Fig. 4 and 5, right—Crystalline Appearance on Melted Nickel Due to Floating Oxide Film. (12×)





thickness equal to wave lengths in the visible spectrum, whether oxide or other types, are very well known among metallographers and have long been used by them for revealing the microstructure of metals and alloys. The color of the film depends on its thickness, and the thickness, for given conditions of attack and especially for similar polished surfaces, depends on the chemical nature of the constituents, on the concentration of solid solutions, and on the crystalline orientation of the grains. Since a very slight variation in intensity of attack causes a marked change in color, this is a process of considerable sensitivity, but, on the other hand, is not specific or quantitative in character because of this color variation with intensity of attack.

Classic examples could be cited of etching by high temperature oxidation to differentiate cementite from phosphide in cast irons (as first proposed by Wüst and Goerens); of picric acid etching in saturated alcoholic solution to differentiate austenite from martensite in hardened steels (originated by F. Robin and Gartner); of etching by sodium hydrate and hydrogen peroxide to detect and study the heterogeneity of concentration of alpha solution in bronzes (as originally suggested by the writer).

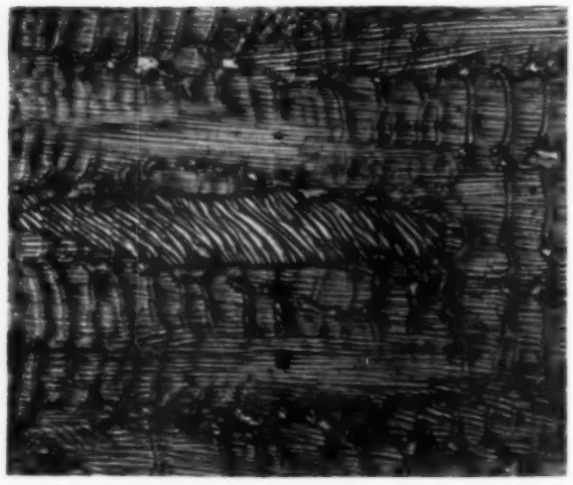
Likewise differences in the orientation of grains may be revealed by this process, which provides one of the best methods of obtaining highly contrasted and very brilliant images of crystalline aggregates—for example, the hot, saturated picric solution for austenite and also for ferrite, the ammonium nitromolybdate reagent of Malette which gives beautiful effects of varied and extremely pure colors, clearly differentiating the grains.

Figures 1, 2 and 3, by courtesy of Mlle. Mayer of Dujardin's laboratories at Dusseldorf, are examples obtained with the last-mentioned reagent. They also demonstrate certain peculiarities that may lead to errors of interpretation. For instance, ruptures in the films can be seen which simulate grain boundaries; in some places the film is raised and lowered along a rectilinear ridge separating two symmetrical areas—one white, which is the grain denuded of its film, and the other colored by the lowered film. This latter might be erroneously interpreted as indicating the presence of twins in the grains.

Figures 4 and 5 (courtesy of R. Castro) reproduce at 12 magnifications the free surface of electrolytic nickel remelted in vacuum in an alumina

(Continued on page 798)

Fig. 6, below—Deeply Etched Austenite, Whose Dendrites Are Marked Zebra-Like, Suggesting a Eutectic. (200×)



A Merry Christmas to All

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Personals

George A. Goepfert, formerly of Independent Pneumatic Tool Co., Aurora, Ill., is now metallurgist at Ross Gear & Tool Co., Lafayette, Ind.

S. K. Oliver, formerly with Electro-Motive Corp., La Grange, Ill., is now with Douglas Aircraft Co. in Santa Monica, Calif.

Jerome Strauss, vice-president in charge of research and development for Vanadium Corp. of America, recently moved from the laboratories in Bridgeville, Pa. to the general executive offices in New York City.

J. Thomas Mahl, H. J. Barton, **C. G. Taylor**, and **E. C. Black** are representatives of the Mahl Taylor Steel Corp., Huntington Park, Calif., formerly the Mahl Steel Co.

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Geogory J. Comstock has been appointed associate professor of powder metallurgy at Stevens Institute of Technology, Hoboken, N. J. **Clair W. Balke** has been appointed assistant professor.

Promoted by Vanadium-Alloys Steel Co.: **M. W. Caruthers**, past chairman, Rhode Island Chapter, to New England manager with headquarters at Springfield, Mass.; **H. F. DeLacour**, formerly of New Haven, to New York district manager with headquarters in New York City.

J. C. Joublanc, formerly chief metallurgist for Harnischfeger Corp., Milwaukee, is now director of metallurgy and research for R. G. LeTourneau, Inc., Peoria, Ill.

Ralph C. Miller, Jr., salesman for Jones & Laughlin Steel Corp., has been transferred from the Pittsburgh to the Philadelphia district.

Named executive vice-president in charge of the newly created alloy steel division of Copperweld Steel Co. at Warren, Ohio: **Frederick J. Griffiths**, for the past three years president of Griffiths-Bowman Engineering Co. and formerly president of Timken Steel & Tube Co.

Henry D. Phillips, formerly chief metallurgist and general superintendent, Dodge Steel Co., Philadelphia, has been made product engineer of Lebanon Steel Foundry, Lebanon, Pa. **Warden F. Wilson** has resigned as Pittsburgh district manager, American Steel Foundries, to become general manager of sales for Lebanon.

Richard A. Schaus has been transferred from Carnegie-Illinois Steel Corp. to Columbia Steel Co. in Pittsburg, Calif.

G. A. Reifsnyder is now with the Timken Roller Bearing Co., Steel and Tube Division, in the mill metallurgical department.

BOTH LIGHT AND TIGHT

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MOLY

Personals

Sydney Nashner has joined Inland Steel Co., East Chicago, Ind., as a metallurgist.

Jack Leeder, formerly with the Crucible Steel Co. of America in Harrison, N. J., is now studying at Massachusetts Institute of Technology for an advanced degree in metallurgy.

Added to technical and research staff of Battelle Memorial Institute: **Robert R. Adams**, a graduate in chemical engineering of Antioch College, and **Arthur R. Elsea**, a recent graduate of Ohio State University.

Cleaveland F. Colburn, formerly assistant metallurgist at Crompton & Knowles Loom Works in Worcester, Mass., is now metallurgist at the Sterling Foundry Co. in Wellington, Ohio.

Harold J. Stein, research engineer of the manufacturing department, Allis-Chalmers Mfg. Co., Milwaukee, has been appointed director of research, chemistry and metallurgy. **J. T. Jarman** will be Mr. Stein's assistant. **W. A. Hambley** has been made metallurgist in the gray iron foundry and **Arthur K. Higgins** metallurgist of the non-ferrous foundry.

John R. Post, Missouri School of Mines 1939, is now junior assistant metallurgist, Acme Steel Co.

Oliver Smalley, president of the Meehanite Metal Corp., Pittsburgh, has been re-elected president of the Meehanite Research Institute of America, Inc. **H. B. Hanley,** foundry manager, American Laundry Machinery Co., and **F. M. Robbins,** president, Ross-Meehan Foundries, have been re-elected vice-president and secretary-treasurer respectively.

Herbert M. Steinberger, formerly metallurgist with the Timken Steel & Tube Co., Canton, Ohio, is now with the Rotary Electric Steel Co., Detroit, as metallurgical service engineer.

L. Norris Hall, Inc. has been appointed Philadelphia distributor for William Jessop and Sons.

Robert Holloway, graduate of Columbia Engineering School, is now in the employ of the Bethlehem Steel Co., Bethlehem, Pa.

International Nickel Co. has made a change in the organization set-up at the Bayonne, N. J. laboratory with **N. B. Pilling**, director; **W. A. Wesley,** assistant director; **E. M. Wise**, staff advisor; and **D. C. West,** manager.

Arthur C. Harper, Jr. has been made product metallurgist, American Steel & Wire Co., Cleveland.

Robert R. Jones is now employed by the Superior Tube Co., Collegeville, Pa.

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Kohler Co.	Kohler, Wis.
Unitcast Corp.	Toledo, Ohio
Dodge Steel Co.	Philadelphia, Pa.
Clark Equipment Co.	Buchanan, Mich.
Gunite Foundries	Rockford, Ill.
Link Belt Co.	Indianapolis, Ind.
American Chain Co.	York, Pa.
Andrew Terry Co.	Terryville, Conn.
Auto Specialties Mfg. Co.	St. Joseph, Mich.
Greenlee Brothers Co.	Rockford, Ill.
National Foundry Co.	Brooklyn, N. Y.
Yale & Towne Mfg. Co.	Stamford, Conn.
Thomas Devlin Mfg. Co.	Burlington, N. J.
General Electric Co.	Several places
International Harvester Co.	Several places
Otis Elevator Co.	Yonkers, N. Y.
Delco-Remy Div.	Anderson, Ind.
Wright Aeronautical Corp.	Paterson, N. J.
Magnus Metal Div.	Several places
Milwaukee Valve Co.	Milwaukee, Wis.
Bohn Aluminum & Brass Corp.	Detroit, Mich.
Sivyer Steel Castings Co.	Milwaukee, Wis.
Chapman Valve & Mfg. Co.	Indian Orchard, Mass.
Nat'l. Mall. & Stl. Cstgs. Co.	Several places
Malleable Iron Fittings Co.	Branford, Conn.
Ohio Brass Co.	Mansfield, Ohio
Eastern Malleable Iron Co.	Wilmington, Del.
Sacks Barlow Foundries	Newark, N. J.
Walworth Co.	Greensburg, Pa.
Stockham Pipe Fittings Co.	Birmingham, Ala.
Belle City Malleable Iron Co.	Racine, Wis.
Crane Co.	Chicago, Ill.
Adirondack Steel Fdries.	Watervliet, N. Y.
Bucyrus-Erie Co.	S. Milwaukee, Wis.
American Steel Fdries.	Verona, Pa.
Michigan Steel Castings Co.	Detroit, Mich.
Draper Corp.	Hopedale, Mass.
American Brake Shoe & Fdry. Co.	Mahwah, N. J.
Gilbert & Barker Mfg. Co.	Springfield, Mass.
Atlas Foundry Co.	Irvington, N. J.
Liberty Foundry Co.	Wauwatosa, Wis.
Cadillac Motor Car Co.	Detroit, Mich.
Allis-Chalmers Mfg. Co.	Several places
Cutler-Hammer Mfg. Co.	Milwaukee, Wis.
Kalamazoo Stove Co.	Kalamazoo, Mich.
Kelsey-Hayes Wheel Co.	Detroit, Mich.
Bendix Products Corp.	South Bend, Ind.
Ross-Meehan Foundries Co.	Chattanooga, Tenn.
Ford Motor Co.	Detroit, Mich.
Buick Motor Co.	Flint, Mich.
American Valve Co.	Coxsackie, N. Y.
Fanner Mfg. Co.	Cleveland, Ohio
Woodruff & Edwards	Elgin, Ill.
Forest City Foundry Co.	Cleveland, Ohio
West Steel Castings Co.	Cleveland, Ohio
Falk Corp.	Milwaukee, Wis.

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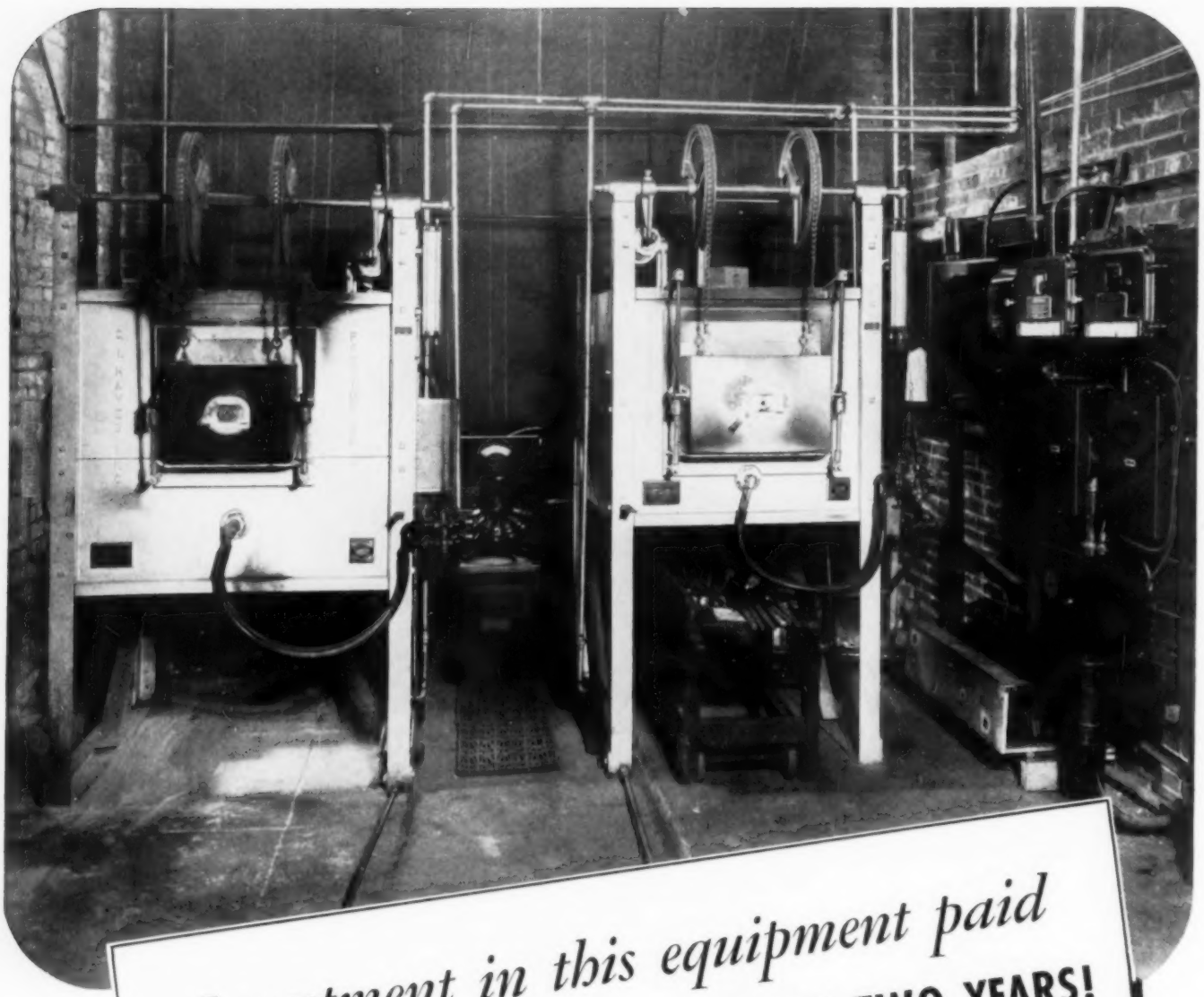

Investment in this equipment paid 100% dividends IN LESS THAN TWO YEARS!

Photo courtesy W. L. Brubaker & Bros. Co.

THIS C. I. HAYES high temperature furnace installation . . . equipped with Globar Brand Electric Heating Elements . . . is used for clean-hardening high-speed steel taps and dies. The equipment has been in service only two years, but has long since paid for itself in reduced finishing costs and increased production.

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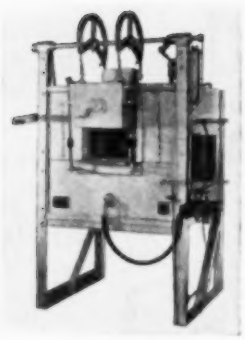

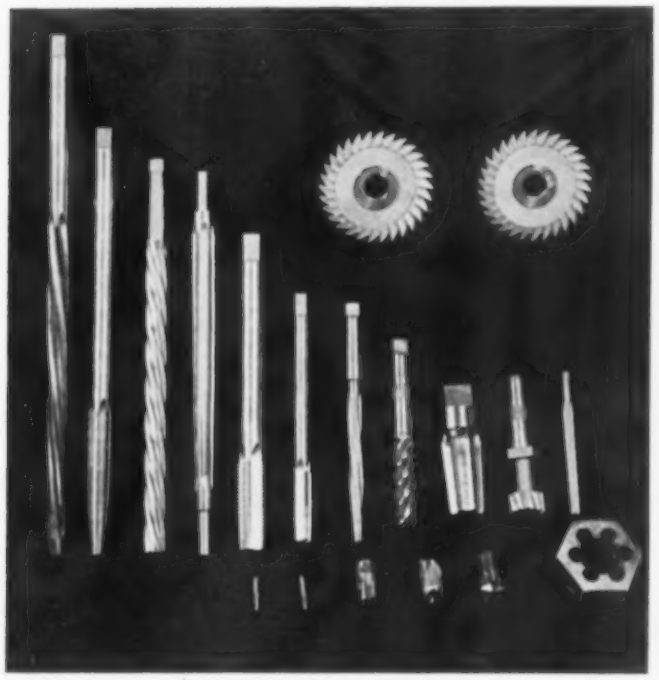

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obtains "elimination of decarburization, reduced finishing costs, increased hardening production, peak quality" with "Certain Curtain" Furnaces.

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An especially fine product for use as a neutral re-heating bath for all types of work within a range of 1350 to 1650 F.

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PARK CHEMICAL COMPANY

DETROIT, MICHIGAN

"Everything for Steel Treating"

Electrolytic Polishing

of iron and steel

The Metallurgist, supplement to *The Engineer*, June 30, 1939, p. 39

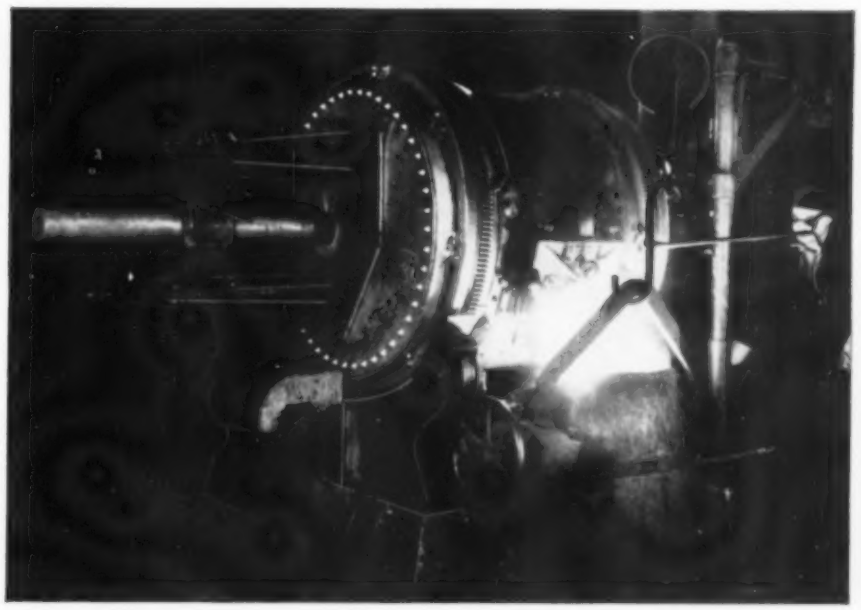
POLISHING of tin for microexamination is particularly difficult, because any mechanical cutting or rubbing will disturb the soft metal to relatively great depths. An electrolytic method which removes the surface layers without mechanical strains, is therefore eminently useful. The fact that the method is applicable to other metals and is much more rapid than conventional methods, lends added interest.

International Tin Research and Development Council has reprinted P. A. Jacquet's original paper on "The Electrolytic Polishing of Tin and Its Application to Microscopical Examination" in its Publication No. 90, February 1939. Polishing of copper, aluminum and certain of their alloys has also been described by the same author in *The Metallurgist* for August 1936 and April 1938. Others applied the method to zinc, cobalt and nickel. It has now been extended by P. Jacquet and P. Rocquet to the polishing of iron and steel for microscopic examination, in an article in *Comptes Rendus*, March 27, 1939, page 1012.

Their object was to simplify the somewhat long and delicate operation of metallographic polishing and to avoid the formation of any deformed surface layer. The electrolyte employed was made by pouring slowly, a little at a time, 765 cc. of pure acetic anhydride into a cooled vessel containing 185 cc. of 65% perchloric acid (density 1.61), and then adding 50 cc. of distilled water. The mixture should be prepared at least 24 hr. before it is to be employed.

The specimen, whose surface has been freed from all foreign matter by abrasion, forms the anode. The cathode may be a plate of iron or of aluminum. The current density should be between 4 and 6 amperes per square decimeter of anode surface. During electrolysis the temperature must not exceed 30° C. (86° F.); hence the electrolytic cell must be kept cool. The solution should be agitated, and since its resistance is high, direct current at a voltage of at least 50 volts is required.

In these circumstances, microscopic polishing of a surface previously prepared with 000 emery paper takes about 4 or 5 min. If the specimen has been finished on coarser emery or has been rubbed on a file, a considerably longer time is taken. When the



Faster Cheaper Melting

The Detroit Rocking Electric Furnace does a faster, cheaper, more accurate job of melting. Cheaper raw materials can be used without impairing the quality of the product. Any size heat is practical. It adapts itself to widely fluctuating production schedules of different alloys any desired number of hours per day. Any type of charge can be run. Through its automatic rocking action and its ability to melt any desired alloy under close control of time temperature and composition, a Detroit Electric Furnace produces a uniformly superior product and a higher percentage yield of perfect castings. Because of its many inherent economies the Detroit Furnace assures a maximum return on its investment — ask the man who uses one.

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ROCKING ELECTRIC FURNACE
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specimen is taken out of the bath it is covered with a viscous brownish-red layer, which is easily removed by washing in a current of water followed by rinsing in distilled water and in alcohol. Subsequent etching with the usual reagents is necessary.

Jacquet and Rocquet have polished, by this means, a variety of annealed and heat treated steels of a wide range of carbon content, showing martensitic, sorbitic, and pearlite structures. White cast iron can be treated, but not iron containing graphite.

The theory of electrolytic polishing is not completely understood. The reddish-brown surface layer surrounding the anode, in which the products of attack accumulate, and which appears to play an essential part in the process of polishing, is thought to contain the complex $[Fe_3Ac_6(OH)_2]\,ClO_4 \cdot 4\,H_2O$, which is known to be very soluble in concentrated acetic acid. The iron dissolved from the anode per minute at a current density of 1 ampere per square decimeter was found to be 16 mg., while the theoretical amount of ferrous ion formed under these conditions would be 17·8 mg. It is probable that the perchloric ions contribute to the oxidation of the ferrous ions in the vicinity of the anode and facilitate the formation of the aceto-ferric ion.

For different types of steel some modification of the electrolyte is said to be desirable. For example, nickel and nickel-chromium austenitic steels can be polished in the solution already described at a current density of at least 10 amperes per square decimeter, but it is preferable to use a solution containing 665 cc. of acetic anhydride and 335 cc. of 65% perchloric acid, at a current density of about 6 amperes per square decimeter. This solution also serves well for 3% silicon steel. For carbon steel the first solution mentioned above may be modified by dissolving in it, by anodic attack, about 0·5% of aluminum. This produces an increase of viscosity, and more energetic agitation may be used with a current density of 3 amperes.

In general, electrolytic polishing of steels is very rapid after a certain experience of the method has been acquired. Specimens of any form and dimensions may be polished on all their faces. The attack of etching reagents is much more active on an electrolytically polished surface than on the same alloys polished mechanically, and a better contrast is obtained between the constituents. Moreover, non-metallic inclusions and flaws are more clearly defined and suffer less risk of damage than in surfaces produced by mechanical polishing.

DEEP cases in SHORTER Treating Time

use du Pont CARBURIZING SALT

DEEP high carbon cases (0.035" and over) are easily obtained on a wide variety of steels in about one-half the usual time for pack hardening and other methods. That is why prominent manufacturers are now using new du Pont Carburizing Salt. At the usual carburizing temperatures this specially prepared cyanide mixture produces high-carbon cases with a very low nitrogen content. Accurate control of the case depth is possible because of the uniform rate of carbon penetration, high conductivity and unusual stability of du Pont Carburizing Salt.

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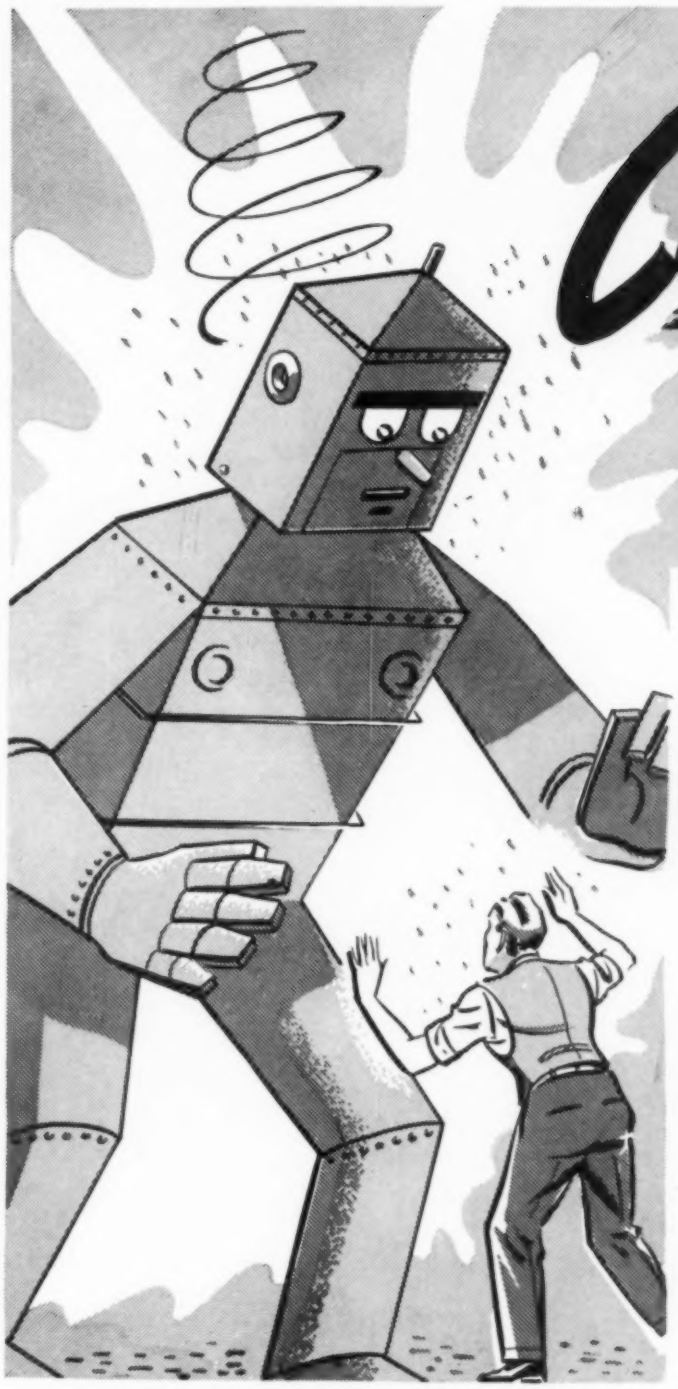

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This as well as many other features you will approve of in Bristol's Pyromaster are fully described in Bulletin No. 507H. Write for a copy.

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New operating principle,—no motion until motion is called for. Quick response to temperature changes. ☆ Simple. Accurate. ☆ Portable. Light weight. Compact. ☆ Fewer moving parts. Less wear. No need for stocking replacement parts. ☆ Easier servicing. ☆ Jewelled galvanometer. Completely balanced. ☆ Vibration-proof. ☆ Round chart models for air or electric control.

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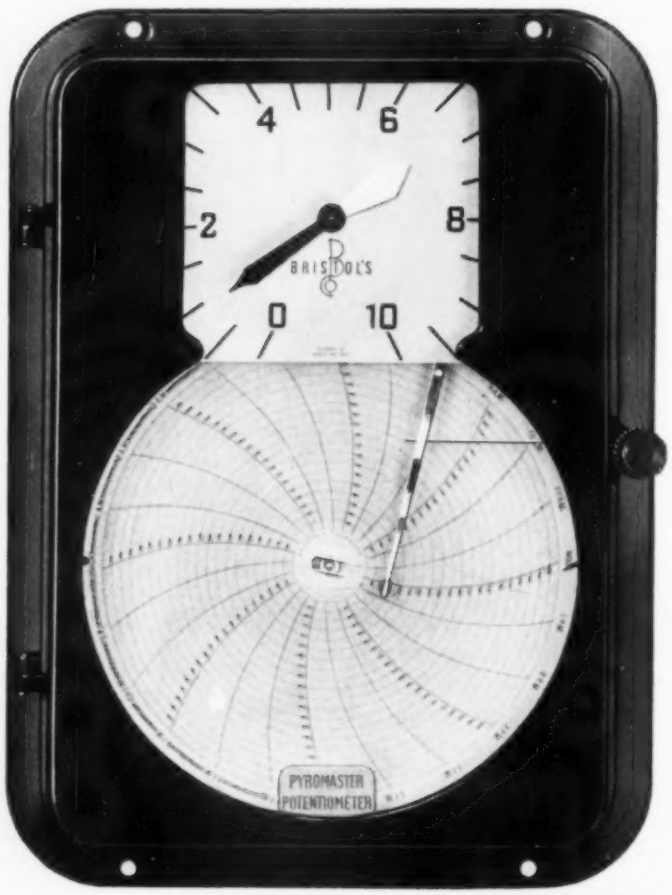

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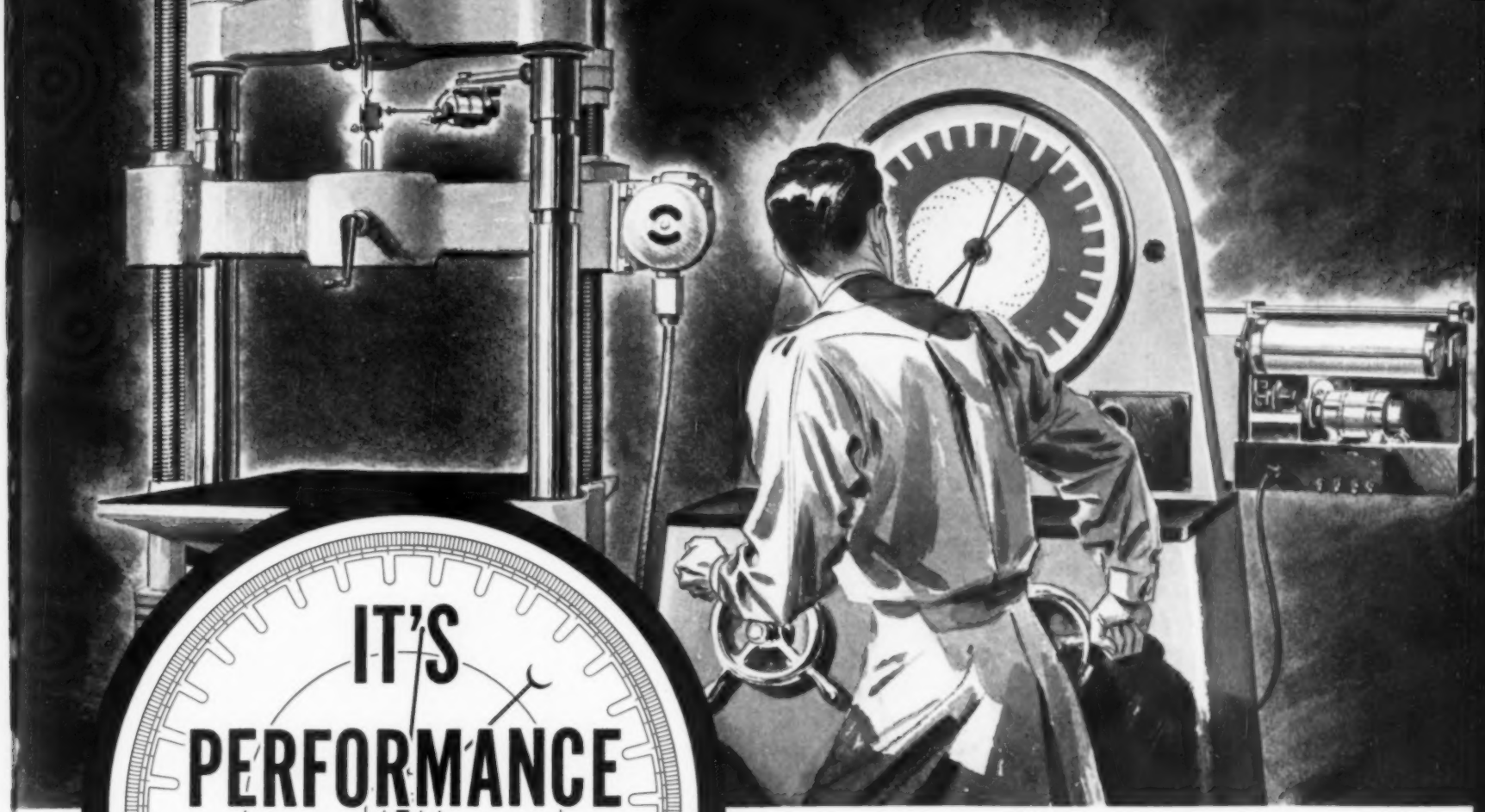
RECORDING and CONTROLLING POTENTIOMETER PYROMETER



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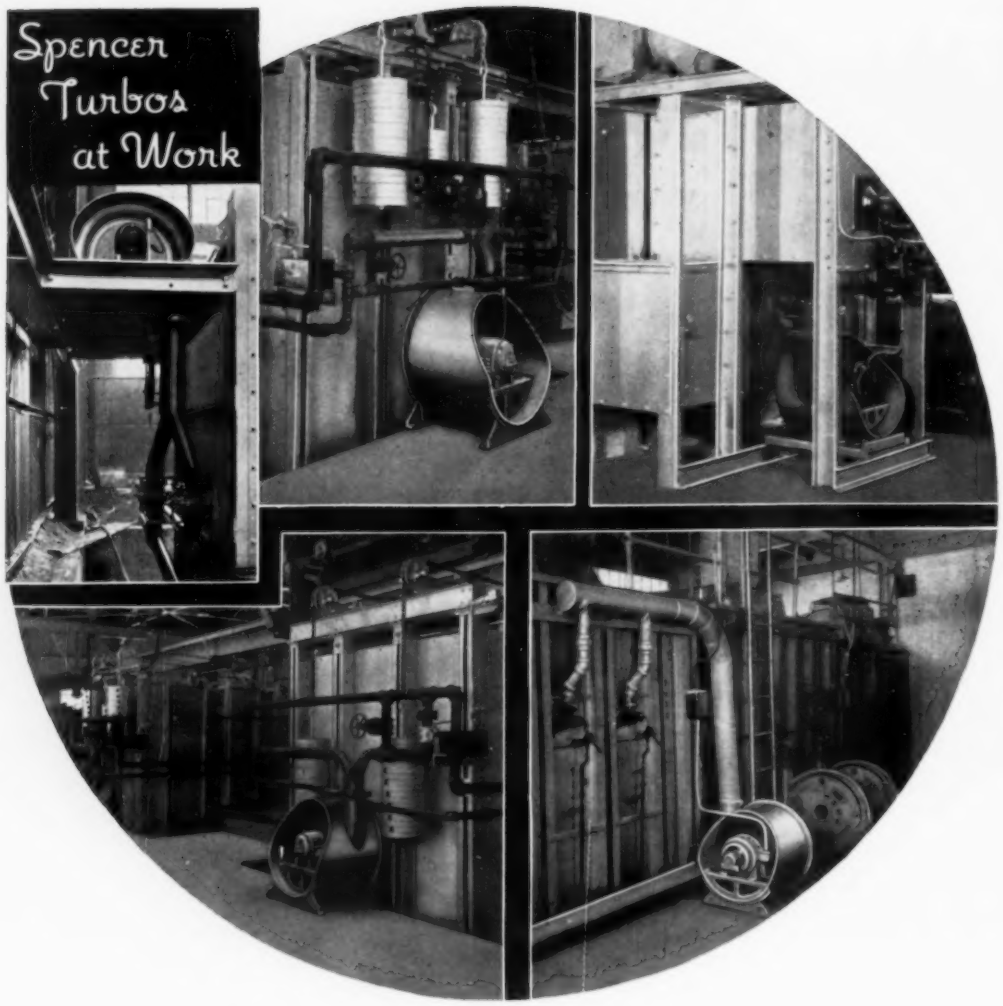

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152-E

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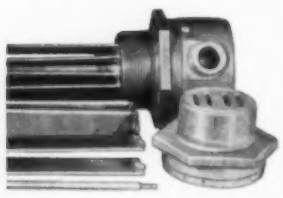
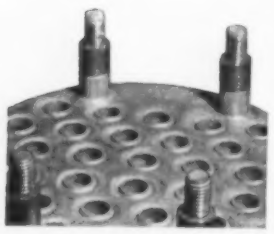


STEEL TO CAST BRONZE



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Industrial Gears

(Cont. from p. 730) eliminated, and the direction and rate of dendritic growth or crystallization properly controlled. A very capable discussion of the casting of steel gear blanks was presented by A. Simonson to the American Gear Manufacturers Association in October 1934.

Gear castings have 0.30 to 0.45% carbon. The usual alloy additions for the larger sizes consist of 0.90 to 1.50% manganese with one of the following: 0.15 to 0.40% molybdenum, 0.50 to 1.25% nickel, or 0.10 to 0.20% vanadium.

A most important step is heat treating to refine the as-cast structure and relieve the casting strains. The as-cast microstructures of a carbon steel and of a manganese-molybdenum steel are contrasted on page 730. To refine this structure requires that the ferrite phase be dissolved by a high temperature treatment at 1625 to 1750° F., followed by cooling in the air or in the furnace. The air cool (normalizing) is preferred because the cooling rate is rapid enough to prevent the ferrite from precipitating in its original massive form.

Low carbon cast steels which are not to be quenched are usually given but the one high temperature treatment. Alloy cast steels are sometimes hardened by a second cooling in air from 1475 to 1550° F. (depending upon the size and composition) followed by a draw to relieve internal strains and bring the hardness within the proper range. So treated, the microstructure of a 0.40% carbon, 1.25% manganese, 0.20% molybdenum steel is illustrated on page 730. Experience has proven that this analysis is a very excellent gear steel, used extensively for such large gears as shown on page 728.

Cast gear steels requiring higher physicals are liquid quenched and tempered. Some users are hesitant to allow either an "air quench" or liquid quench, forgetting that most large forgings are "air quenched" or normalized to obtain higher physicals and better grain refinement. There are certain limitations of casting size and shape which demand a full anneal, but these are recognized by gear metallurgists.

Recently, developments in the field of centrifugal casting have indicated that the process will find application for gear blanks. Equipment and technique will obviously have to be developed so as to reduce the cost to a point commensurate with the added benefits.

Best results from oil fired furnaces depend on accurate control of atmosphere in the heating chamber. With the North American AIR OIL RATIOTROL perfect control is assured at every instant.

The RATIOTROL proportions the flow of fuel oil and its combustion air by controlling pressures and making them dependent on each other. Air pressure alone becomes the dominant factor while number of burners and their individual setting have no effect on the operation.

Non varying air-oil ratios are maintained when changing size of fires . . . turning individual burners up and down . . . changing air or oil supply . . . adjusting air-oil ratio on any individual burner.

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MANUFACTURING COMPANY . . . . CLEVELAND, OHIO

Compact, self-contained, with an open legible chart, the new series of Foxboro Controllers provides extreme sensitivity without delicate parts, and new simplicity in a dual-purpose instrument.

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Foxboro's *new* series of Potentiometer Recording Controllers offers these 3 unduplicated features:

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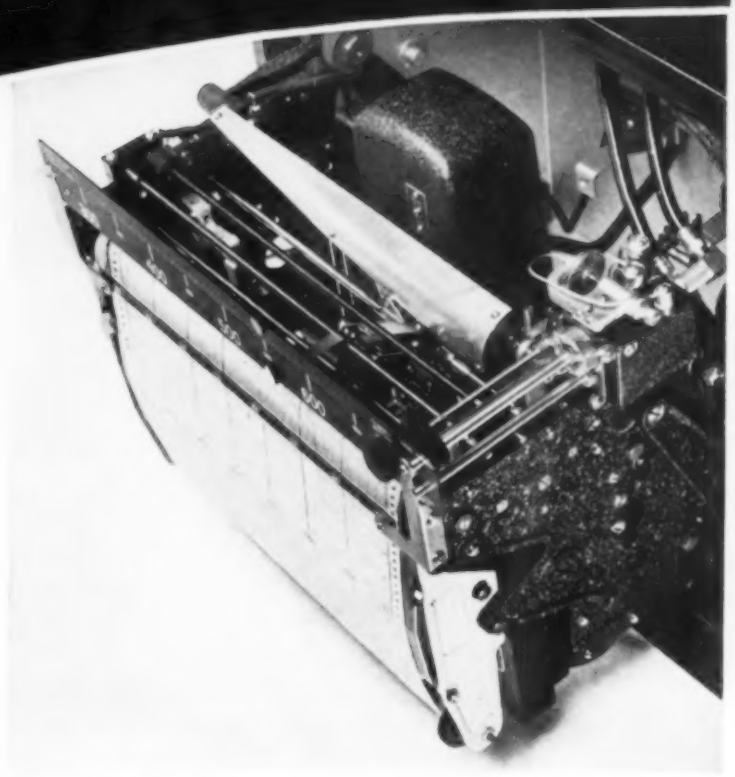
This cam positions a friction roller by which the movement of the integral slide-wire contact, recording and control actuating carriage is positively determined.

2 **INTEGRAL RECORDING AND CONTROL MECHANISM.** In the new Foxboro Controllers, measuring, recording and controlling are, *and cannot fail to be*, exactly coordinated operations. The slide-wire contact, recording pen and cam follower actuating the control cam are assembled as a unit on the same rigid carriage. No linkages, belts or gears transmit the position of one to the others. Simplicity here means accuracy in service.

3 **COMPLETE FLEXIBILITY IN CONTROL.** The control system is affixed directly to the shaft of the cylindrical control cam, eliminating linkages and making for a compact, self-contained unit. The rotary motion of the control-cam shaft makes for extreme simplicity in providing for multi-point electrical control, electrical throttling control, or STABILOG air-operated throttling control, as required by application conditions.

CONTROL THE PROCESS AND

TEMPERATURE VARIATION



Shown at right is the Pyrometer model incorporating the Stabilog system of air-operated throttling control—an instrument competent to meet the most difficult conditions of "upset" or process lag *smoothly*, without "hunting" or drifting of the control point. Note accessibility of interior.

NOW...

you can buy a completely modern Pyrometer Recording Controller specifically designed to give the type of control action that your furnace or processing conditions require . . . a self-contained, dual-function instrument with the control precision previously found only in single-purpose Potentiometer Controllers.

AIR-OPERATED CONTROL is furnished for open-and-shut action, or for throttling action, with or without automatic reset.

ELECTRIC-OPERATED CONTROL is available for simple "on-off" operation, or "high-low" (plus neutral or normal) or for throttling action with manual or automatic reset.

Other variations include control with multi-point recording. Signals, alarms, or safety shut-down can be included.

"On-off" or *"high-low"* control has knife-edge selection with no dead spot, thus preserving the precision provided in the detecting mechanism. *Throttling controls* carry out, in the control system, the sensitivity which originates with the measuring and detecting operations. *Reset* and other auxiliary actions are properly designed to meet the conditions of load changes. *Stabilog control* has been perfected through years of study of the characteristics of difficult process problems.

Ask your local Foxboro man for complete details on the new instruments and the possibilities they raise for improved recording and control in connection with your own furnaces or processing needs. He can aid you in determining the particular type of these or other Foxboro instruments that will meet your own conditions in the one best way. Or, write direct for full specifications to **The Foxboro Company, 52 Neponset Ave., Foxboro, Massachusetts, U. S. A.** Branch offices in 25 principal cities.

FOXBORO

REG. U. S. PAT. OFF.

RECORDING / CONTROLLING · INDICATING

Certified ACCURACY and RESPONSE

Instruments

TEMPERATURE · LIQUID LEVEL
PRESSURE · FLOW · HUMIDITY

YOU CONTROL THE PRODUCT

Zinc alloys

(Cont. from p. 748) caused by the traces of lead and cadmium still present, and in addition, magnesium also causes considerable hardening. Zinc and copper form two conjugate solid solutions, epsilon and eta, both hexagonal close-packed with lattice parameters varying as to the number of copper atoms present.

Combinations of these two principal metals with zinc have proven very useful in the non-ferrous fabrication industry, so that at the present time many millions of small parts are being made. Compositions range from 4% Al, 1% Cu to 10% Al, 2% Cu, the latter where strength and corrosion resistance are particularly important. As above remarked a few hundredths per cent of magnesium is desirable. The microstructure of a freshly cast piece of 10% Al, 2% Cu zinc is a mixture of rapidly etching alpha and slowly etching beta crystals, but the latter spontaneously transform into alpha plus gamma on storage at room temperature, the reaction being fairly rapid, once under way, and being apparently complete in 12 days.

Pressing is done in the same machinery and with the same dies as for brass. Proper working temperature is between 300 and 500° F. Difficult shapes may require a roughing and a finishing operation. Present uses are for automobile and builders' hardware, small levers, wing nuts, hose fittings, small brackets and padlocks. Many of the parts are plated with nickel, chromium or brass, and no difficulties have arisen in this connection, parts being quite easily plated and giving good results in service.

Extruded rod is the usual raw material for hot pressings. Many thin and ribbed sections of moldings have also been extruded, as well as tubes. Thin-walled tubes are under development. Wire can readily be drawn from extruded rods, and rivets have been cold headed from this wire on a semi-commercial scale.

Although the extruded rod as supplied costs about the same as brass, the prices of the finished products are on the average higher than for brass. This can be accounted for partly by the increased wear of the tools and partly by the higher percentage of rejects, although the latter will be reduced in time as experience is gained. Actually there is no reason why the finished parts should soon not be produced as cheaply as brass pressings.

Merry Christmas—men of ASM!

It's been fun working, planning — and playing with you during the past years.

You whose minds *create* that idle hands may *build* as well as *eat* and *vote* are still the true Pilots of Progress under any system.

A bright future lies ahead for American metallurgy — of this you are an indivisible part — and from this — your work — you will create a PROSPEROUS NEW YEAR. MAY IT ALSO BRING TO YOU AND YOURS THE FULLEST MEASURE OF HEALTH AND HAPPINESS — PEACE AND SECURITY.

MAY EACH SUNRISE ADD TO YOUR JOYS AND OPPORTUNITIES, AND EACH SUNSET BRING YOU CONTENTMENT.

MAY ALL YOUR SHIPS COME SAFELY THRU THE MINE FIELDS OF ADVERSITY, ESCAPE THE TORPEDOES OF BERLIN AND WASHINGTON AND REACH YOUR PORT OF HEART'S DESIRE.

THAT — FRIEND — IS OUR FERVENT WISH.

GENERAL ALLOYS COMPANY

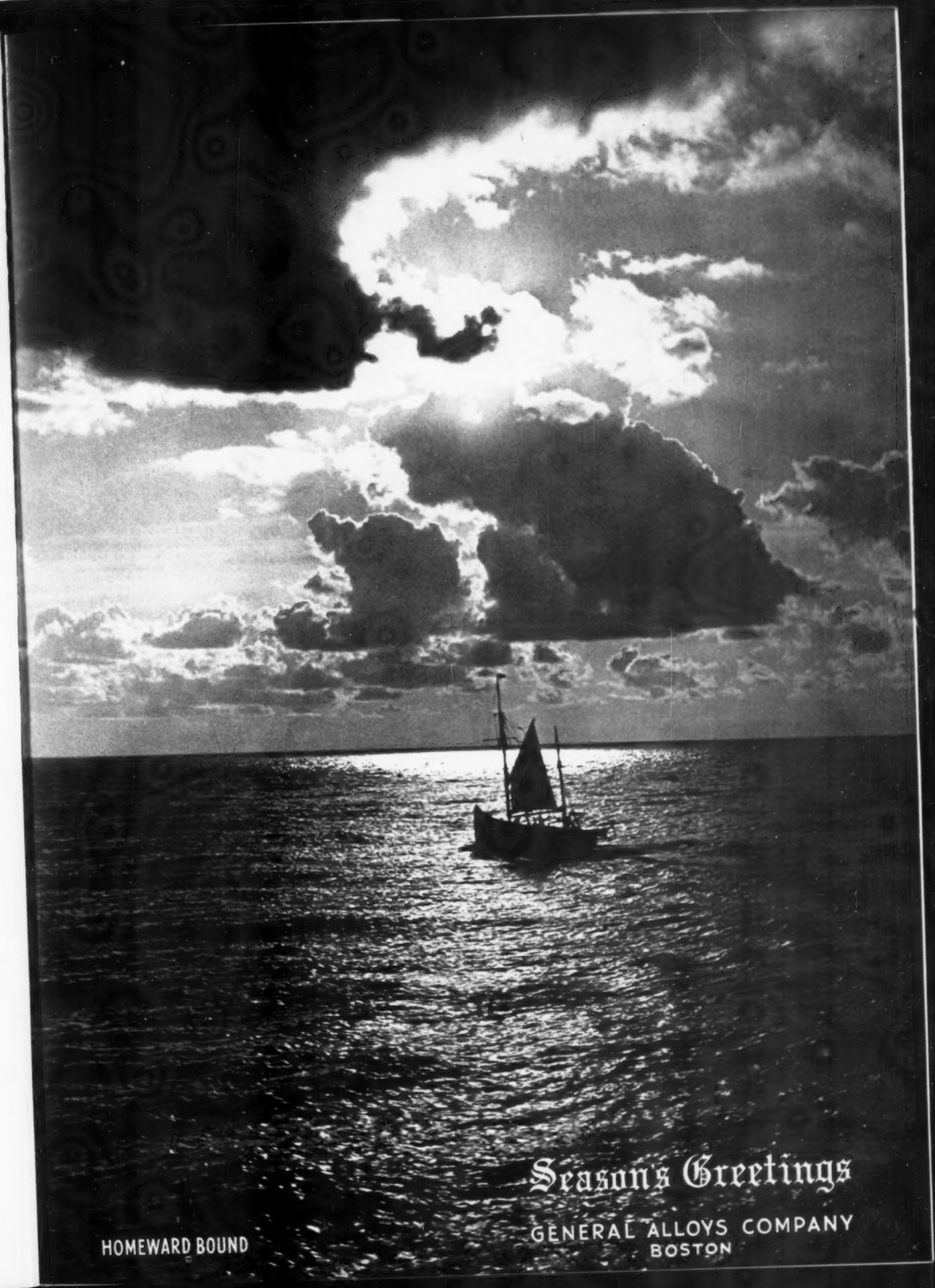
P.S. Only reason for bringing this "balcony" on to the next page is to avoid imposing inferior copy on superb photography.

NO GUESSWORK
in tempering these bolts

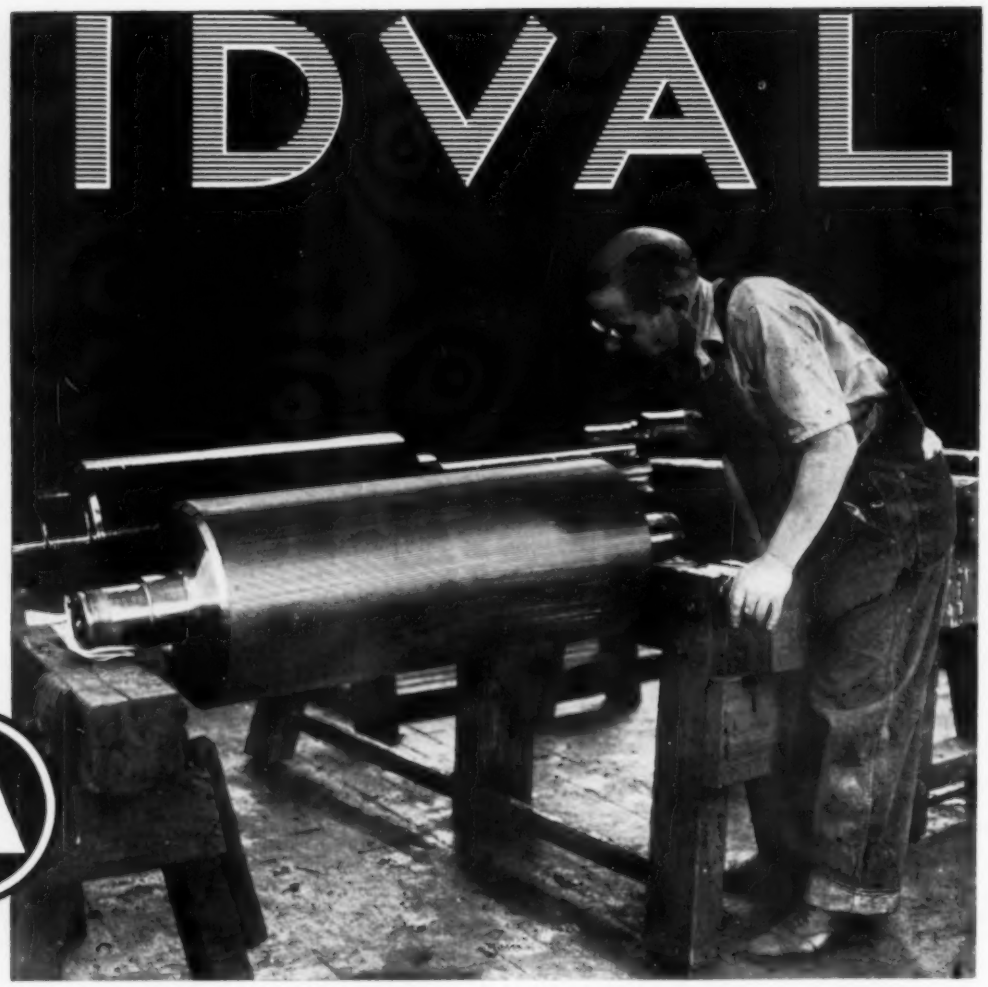
The Despatch tempering furnace shown above is in the plant of the Minneapolis Moline Power Implement Company. It has eliminated all guesswork in tempering and drawing gears, bolts, or bearings . . . producing a uniform hardness, regardless of the size of the load.

This is just one of many performance records set by Despatch recirculating furnaces. Write today for interesting furnace catalog.

DESPATCH
OVEN COMPANY . . . Minneapolis, Minn.
OVENS - DRYERS - FURNACES and AIR HEATERS


Season's Greetings
GENERAL ALLOYS COMPANY
BOSTON
HOMEWARD BOUND

MIDVALE



HARDENED AND GROUND ROLLS FOR SPECIFIC PURPOSES

THIS herring boned surface roll was made for a specific installation—as are most rolls today. But all have one essential in common—they must stand up. Otherwise two things happen. They lower the quality of output—and they delay deliveries.

Your customer may never see these rolls—but he quickly sees any results of roll failure. Few firms in the world have made as many, or as varied rolls as Midvale. We have made them for rolling practically every type of metal. That experience can save you money—and trouble.

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minimizes scaling and de-carburization

The Ridge Tool Company

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TRADE RIDGID MARK
PIPE TOOLS "LocGrip" EXTRACTORS
Elyria, Ohio

CABLE ADDRESS
RIDGETOOL
ELYRIA (OHIO)
ALL CODES USED

The Brown Instrument Company,
Philadelphia, Pa.

Gentlemen:

Recently we installed a Brown Analy-Graph in our Heat-Treating Department on two of our controlled atmosphere furnaces.

The instrument was in operation only a short while when we discovered from the erratic curve record on the chart, that the atmosphere in one of these furnaces was very unsteady. Upon investigation, we found that this was due to two causes -- first, the furnace had developed serious leakage, and second, the vent was not properly located. By repacking the furnace and relocating the vent, we have completely eliminated this condition.

The Analy-Graph enables us to place complete confidence in our heat-treating department. Now we know, exactly and at all times, the conditions under which our cutter blades, our vise jaws, our wrench jaws or our chasers, are hardened.

We have used the Analy-Graph for eight months -- we would not think of operating without it now.

Yours very truly,

THE RIDGE TOOL COMPANY
W. O. Thewes

W. O. Thewes, Supt.

WOT:MP

The Brown ANALY-GRAPH records the slightest variation in furnace atmospheres, whatever the cause — whether combustion is complete or incomplete. The metallurgist or furnace operator can change the atmosphere specifications at any time to suit the metal and work in hand. He has positive assurance, in advance, that the heat treatment will produce exactly the desired characteristics regardless of day, time, weather or season of year.

The Brown ANALY-GRAPH effectively aids the heat treater to produce clean, properly treated work at the lowest possible cost. Write for Bulletin 92-3. THE BROWN INSTRUMENT COMPANY, *a division of Minneapolis-Honeywell Regulator Co.*, 4503 Wayne Avenue, Philadelphia, Pa. Offices in all principal cities. Toronto, Canada: 117 Peter Street—Amsterdam-C, Holland: Wijdesteeg 4 — Stockholm, 16, Sweden: Nybrokajen 7 — England: Wadsworth Road, Greenford, Middlesex.

BROWN DIVISION INDUSTRIAL INSTRUMENTS

BROWN FURNACE ATMOSPHERE ANALY-GRAPH RECORDER

To Measure and Control is to Economize

Contributors

METALLURGY of large gears such as described in the leading article in this issue requires a sound knowledge of mechanical as well as metallurgical principles. The author, **Edward J. Wellauer,** is therefore well qualified by undergraduate training in mechanical and electrical engineering at Marquette University and a master's degree in metallurgy from University of Wisconsin. He is likewise a member of both ⊜ and the American Society of Mechanical Engineers. Mr. Wellauer has been in charge of metallurgical work for the Falk Corp., Milwaukee, for several years and was recently appointed research engineer.

⊜ ⊜ ⊜

Twelve years practical experience in the shop, combined with the study of mechanics and metallurgy at University of Cincinnati and Case School, and topped by considerable aptitude with a pen, result in the useful article on press tool failures told from the operator's viewpoint by **C. E. Bretney.** Mr. Bretney's principal function in the Speed Nut Division of Tinnerman Stove and Range Co., Cleveland, is to coordinate the production and engineering departments and to design dies. Before coming to Tinnerman he held various positions with an ammunition plant in Cincinnati and a spring plant in Cleveland, including such jobs as press operator, production clerk, tool maker, supervisor of metal stampings division, and tool designer. He has written on press work and production problems for other trade publications.

⊜ ⊜ ⊜

N. T. Belaiew, who writes so fluently and sympathetically of Tschernoff and his works, was born into a distinguished military family in prerevolutionary Russia. He was educated at the best military schools and after three years active service returned to resume his studies at the Michael Artillery Academy, where he came under the direct influence of Professor Tschernoff. In 1906 he was admitted to the faculty and in subsequent years did some of his most important work on crystallization of steel and the Widmanstätten structure. He served in the artillery in the World War until invalided. An expatriate since the Revolution, Colonel Belaiew maintained a private laboratory in England and lectured at the Royal School of Mines. Since 1931 he has been consulting engineer for the Welding Institute in Paris. Belaiew's work on crystallization ranks him as a metallurgical pioneer in his own right; he studied not only under Professor Tschernoff but also under Wüst in Germany and LeChatelier and Osmond in France. In 1937 he was awarded the Bessemer Gold Medal of the British Iron and Steel Institute.

⊜ ⊜ ⊜

Another brief but interesting article of a practical nature in this issue is on sulphide inclusions and emanates from the metallurgical laboratory at the South Chicago plant of the Republic Steel Corp. The author, **George K. Manning,** has been at Republic since last February. He was graduated from Franklin College in 1932 with a baccalaureate in mathematics and physics, and received a master's degree in metallurgical engineering from University of Michigan in 1938.

⊜ ⊜ ⊜

Two distinct styles of writing are mastered by **John S. Marsh,** one in his weighty volumes for the Alloys of Iron Research, and the other in his vivacious account of the temperature symposium (page 731). Marsh joined the staff of the Alloys of Iron Research of the Engineering Foundation in 1930; he has been its physical metallurgist and associate editor since 1933. Doing graduate work at Penn State heading toward a Ph.D., Marsh quit in 1927 to take a position with the Aluminum Co. This was followed by a year with Keuffel and Esser Co. before joining Engineering Foundation.

Nicholas T. Belaiew

Edward J. Wellauer

George K. Manning

C. E. Bretney

To Avoid *Distortion* use the new *Ni-Carb* process

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for surface hardening

Assembly costs are sometimes exorbitant because of the high percentage of parts which have warped in hardening. By "Ni-Carbing" and slow cooling (quenching can be omitted) a hard surface is obtained and warping and size change are reduced to a minimum. "Ni-Carb" is being adopted for this reason and many others such as:

1. A tough hard case which adheres very tightly to the core and has no tendency for exfoliation.

2. "Ni-Carb" can be used on any grade of steel, steel castings, cast iron and malleable iron.

3. The extent to which the process can be varied to meet specific requirements.

4. Economy in processing.

Send us a sample of your work for a demonstration.

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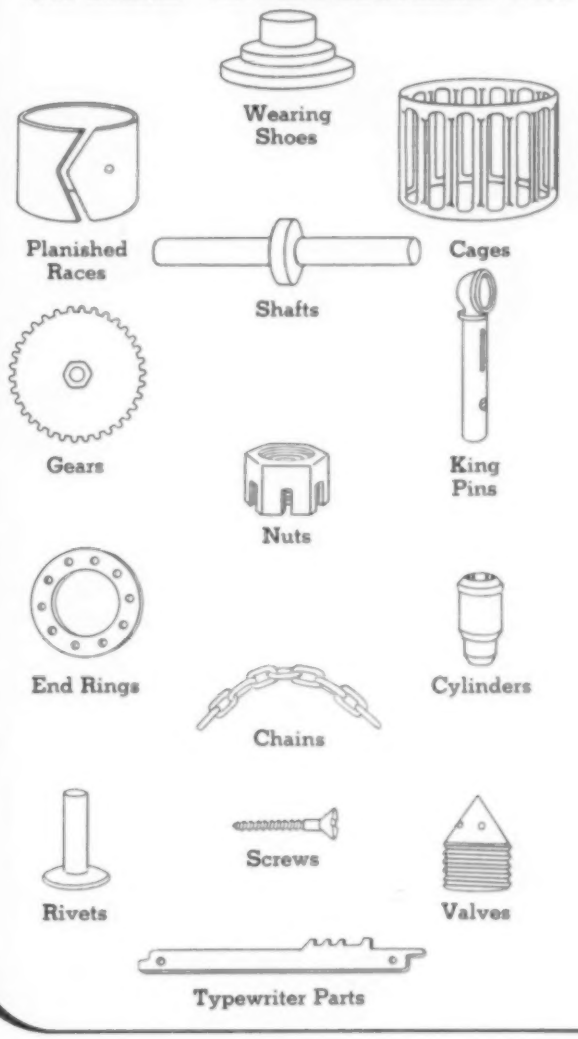

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ELIZABETH, N. J.

AMERICAN GAS FURNACE CO. PIONEERS IN 1878 LEADERS TODAY

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Use COLMONOY for Those Tough Jobs

The rough casting of Colmonoy No. 6 shown above is brazed in place on the base and then machined. It has proved so satisfactory in operation that it is standard equipment with a prominent manufacturer of centerless grinders.

The hard, diamond-like crystals of patented chromium-boride ($Cr B_2$) distributed throughout all Colmonoy hard-facing materials are your best insurance against the effects of wear, abrasion and corrosion. Insist on Colmonoy for the tough jobs.

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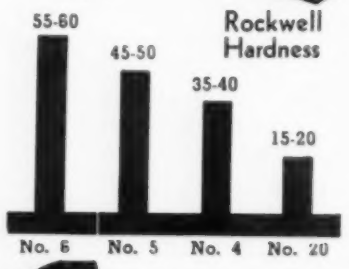

Colmonoy is available in four grades of hardness, as shown in the chart. No. 6 has maximum resistance to abrasion and corrosion. No. 5 is for jobs requiring extreme abrasion resistance plus machinability. Nos. 4 and 20 are suited to repair work, such as mending defects in cast iron or smoothing flaws in die casting molds.

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Superdie High Carbon - High Chromium Steel has helped thousands of users this year to get economical and satisfactory results.

Stocks are being maintained and deliveries are the best.

It pays to use Good Tool Steel.

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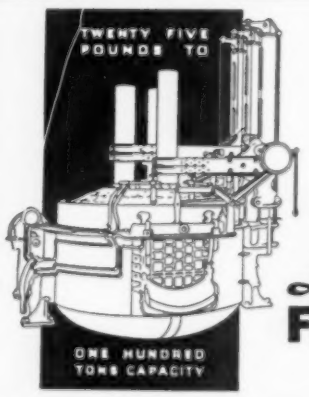

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The largest group of men ever to register for an ASM educational course heard Dr. Edgar C. Bain, noted metallurgical authority of the U. S. Steel Corp., deliver his five lectures on "Functions of the Alloying Elements in Steel" at the Chicago National Metal Congress.

Their enthusiastic reception of Dr. Bain's remarks on carbon steels . . . alloying elements . . . hardenability . . . tempering, was a tribute to the painstaking effort which went into this series. Dr. Bain presents his material in concise, clearly understandable language—making simple a subject which is of fundamental importance to every member of the American Society for Metals.

If you were one of the four or five hundred men who gathered daily to hear these lectures during the Metal Congress you will be glad to learn that the complete series is now available in a well-made, 6x9 book containing 312 pages with 186 interesting illustrations. Until December 15 this book will be sold at the introductory price of $3.00 per copy. (After this date $4.00.)

And if you didn't get to the Metal Congress, you will treasure this book more than ever . . . for it brings you first-hand information on this important subject from one of the most respected authorities in the metal industry. Use the handy coupon below to send for your copy TODAY.

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Shown at the left is a typical group listening to Dr. Bain present his educational series at the recent Chicago Metal Congress.

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Please send me a copy of Dr. Bain's new book "Functions of the Alloying Elements n Steel" at the special introductory price of $3.00. I am enclosing this amount in ash ( ), money order ( ), check ( ).

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HELPFUL LITERATURE

Testing Catalog

A loose-leaf binder provides a handy reference catalog of testing machines made by Steel City Testing Laboratory. Universal hydraulic machines, Brinell testers, bend, impact, tensile, and ductility testers are some of the products. Bulletin Oy-140.

Burner Economy

Interesting photographs and text are used by Surface Combustion Corp. to show that a choice of 47 different types and more than 400 different sizes is sure to give economy in operation. Bulletin Ca-51.

Cadalyte "39"

A new technical service manual on CADALYTE "39" for cadmium plating has been issued by the Electroplating Division of Du Pont. Cites recent improvements and changes in the product, and gives detailed operating instructions and methods of analyses. A table of costs and time required for specified deposits is included. Bulletin Gb-29.

Bright Annealing

Various types of electric and fuel-fired furnaces built by the Electric Furnace Co. for bright-annealing wire, tubing, strip and other products are described in an 8-page folder. Bulletin Lb-30.

Cinch Steel Cement

How Cinch steel cement saves high speed steel and Stellite by permitting the using up of short pieces is told in a bulletin by Claud S. Gordon Co. Bulletin Ka-53.

Chapmanizing

Chapmanizing, the method of surface hardening steel with nitrogen, is described in a very attractive booklet of Chapman Valve Mfg. Co. Information is given on the method itself and on its metallurgical advantages. Bulletin Ob-80.

Welding Pipe Lines

An improved welding method used in the construction of over 5000 miles of cross-country pipe lines is discussed in a 32-page illustrated booklet published by The Linde Air Products Co. Bulletin Da-63.

Electromet Review

A very attractive house organ which gives news and views of alloy steels and irons, but is mostly concerned with stainless steels. Electro Metallurgical Co. publishes it. Bulletin Ox-16.

Low-Alloy Steel

A new folder on Mayari R, Bethlehem's high-strength, corrosion resisting steel, is colorfully illustrated with views of its various uses. Bulletin Kc-76.

Compressor Data

General information on the application of blowers to gas and oil burners, and miscellaneous applications for other types of work are included in a 12-page "Turbo Compressor Data Book." Useful tables and charts are included. Spencer Turbine Co. Bulletin Dy-70.

Screw Machining

Screw machine products of aluminum are treated in authoritative and extensive manner in a booklet of Aluminum Co. of America. Besides general data on screw machining, a number of very useful tables appear. Bulletin Ar-54.

High Tensile

The 19 advantages that USS Cor-Ten steel offers to railroads and other industries are attractively presented in a 68-page book on this new low cost, high tensile steel published by United States Steel Corp. Bulletin Ka-79.

Brazing Alloy

Sil-Fos for joining brass, bronze, nickel, nickel silver, extruding brass and bronze, monel metal and other non-ferrous metals and alloys fusing above 1300° F. is a product of Handy & Harman, described in Bulletin Jy-126.

Ingot Production

"The Ingot Phase of Steel Production" is the title of a book defining the principles of quality ingot production followed by many well-known steel manufacturers. Gathmann Engineering Co. Bulletin Ka-13.

Heat Resisting Alloys

Authoritative information on alloy castings, especially the chromium-nickel and straight chromium alloys manufactured by General Alloys Co. to resist corrosion and high temperatures, is contained in Bulletin D-17.

Electric Furnaces

A new catalog on electric furnaces and pyrometers has been released by the Hoskins Manufacturing Company. For anyone who does any kind of heat-treating, brazing, or uses heat-resisting castings. Bulletin Hc-24.

Hardened Gearing

Extremely valuable technical information on heat treated hardened gearing, including treatment, control and quenching, comparison of properties, etc., is included in a booklet by the Westinghouse Electric & Mfg. Co. Bulletin Hc-134.

Pure Metals

Pure, carbide-free metals are described and applications suggested in a pamphlet published by Metal & Thermit Corp., who make pure tungsten, chromium and manganese in addition to the ferro-alloys. Bulletin Ma-64.

Vapocarb-Hump

Vapocarb-Hump, the triple-control method for heat treatment of steel, is described in a 36-page catalog issued by Leeds & Northrup Co., in which a special effort has been made to show how this method gives complete control of tool surface, shape and structure. Bulletin Cb-46.

Annealing Furnace

The interesting "Top Hat" Cover Annealing furnace just perfected by Continental Industrial Engineers, Inc., is described in a bulletin of value to furnace users. Bulletin Nc-154.

Welding Stainless Steels

A 24-page technical bulletin, giving important information for the engineer, designer or welding operator on the welding of stainless steel, is available through the Arcos Corp. Bulletin Hc-191.

Atmosphere Control

A device manufactured by Brown Instrument Co. and known as the "Analy-Graph" records minute changes in the chemical composition of a furnace atmosphere. How it works is told in Bulletin Ka-3.

Tube Alloys

Practical data on tube alloys compiled by the Technical Department of the Driver-Harris Co. simplifies calculations by providing derived constants in the shape of tables and formulae. Handy conversion tables included. Bulletin Ib-19.

Testing and Controls

An up-to-the-minute booklet on foundry sand testing and control equipment is just off the press. Published by Harry W. Dietert Co. Bulletin Ec-198.

Machining Steel

An 80-page book of general and specific information on steels, including tables of recommended cutting speeds and feeds for many grades of carbon, alloy and stainless steel, has been made available by the Union Drawn Steel Division of Republic Steel Corp. Bulletin Nc-8.

Arc-Welding Electrodes

A very helpful 40-page booklet for arc-welders and those interested in welding in general has been made available by the General Electric Co. Bulletin Nc-60.

General Data Book

Valuable reference and data are contained in a book by Joseph T. Ryerson & Son, Inc., which gives metallurgical definitions, heat, hardness, and numerical equivalent tables as well as many valuable operating facts. Bulletin Nc-106.

Design

Designing greater sales appeal into products is explained in a colorful 8-page booklet for anyone who contemplates using, or is using, Stainless Steel, issued by the Carpenter Steel Co. Bulletin Nc-12.

Heat Treating Line

An attractive catalog of heat treating products is published by Park Chemical Co. It starts out with a very useful diagrammatic thermometer showing the temperature and ranges for the various heat treating, melting and other processes requiring heat. Bulletin Oy-141.

Portable Potentiometer

An extremely versatile indicating potentiometer with precise balancing, quick standardization, and easy-reading scales is described and illustrated in a new folder by the Foxboro Co. Bulletin Nc-21.

Hardening Furnace

A new pamphlet which describes "Certain Curtain" furnaces made by C. I. Hayes, Inc., will be particularly interesting to those with hardening problems. Bulletin Nc-15.

Closer Temperatures

Closer temperature control than is possible with any Mechanical Controller is explained in a 12-page illustrated pamphlet just released by Wheelco Instruments Co. Bulletin Nc-110.

Degreasers

An interesting line of portable degreasers which can be taken to the work—instead of bringing work to the degreaser—is shown and described in a colorful folder by the Phillips Manufacturing Co. Bulletin Nc-254.

Moly Matrix

Climax Molybdenum Co.'s little monthly newspaper contains many interesting and informative articles. Get the latest issue—Bulletin Ax-4.

HELPFUL LITERATURE

Heat Treat Chart

Heat treaters everywhere should find a heat treating wall chart complete with S.A.E. specifications a very valuable addition to their shops. Published by Chicago Flexible Shaft Co., manufacturers of Stewart industrial furnaces. Bulletin Ka-49.

Galvanizing

An informative, historical, simple digest of galvanizing forms a guide to longer life for iron and steel products. This handsome, handy, 24-page book beautifully printed in color is distributed by American Hot Dip Galvanizers Association, Inc. Bulletin Ea-167.

Carburizing Salt

A technical service bulletin describing a new development—Du Pont Carburizing Salt—for the economical production of deep high-carbon cases on plain carbon and alloy carburizing steels . . . available through DuPont. Bulletin Dc-29.

Portable Hardness Tester

The "Telebrineller" is described in a new bulletin as a simple, rugged, flexible instrument that accurately determines Brinell hardness of surfaces and objects inaccessible to conventional testers. Total weight, 6½ lbs. Teleweld, Inc. Bulletin Dc-96.

Oil Burners

North American Mfg. Co. offers a bulletin describing improved low pressure oil burners, one type especially designed for automatic control and ideally suited for use with proportioning control valves. Bulletin Na-138.

Dust Control

Dust control in the plant is as important as dust control on the prairies, American Foundry Equipment Co. points out in a booklet describing their "Dustube" dust collectors. Bulletin Id-112.

Bessemer Steel

Jones & Laughlin Steel Corp. has for distribution reprints of the paper by C. C. Henning on "Manufacture and Properties of Bessemer Steel" that received the Robert W. Hunt Award of the A.I.M.E. Bulletin Ca-50.

More Dust Hog

Those who have been following the Dust Hog series of the Pangborn Corp. which analyzes the cost of dust to industry, will appreciate the fifth and sixth folders of the series which are now available. Bulletin Lc-68.

Direct Reading Brinell

Production testing on parts of any shape without spotting or the use of a microscope is possible through the new Direct Reading Brinell machine described in a folder by the Detroit Testing Machine Co. Bulletin Gc-245.

Contour Metal Shaping

A very colorful, plastic-bound booklet containing Job Sheets on metal shaping jobs will be helpful to men in Shipbuilding, Plastics, Silverware, and Automotive fields. Available through Continental Machines, Inc. Bulletin Lc-170.

Metallographic Reference

Nearly one thousand technical books and reference papers on Optical Principles in Metallography are listed in the new Metal Analyst just released by Adolph I. Buehler. Bulletin Lc-135.

Recording Control Equipment

Now available from Baldwin-Southwark Corp. is a new 16-page bulletin illustrating and describing Southwark's complete line of stress-strain recorders and extensometers. Bulletin Bc-67.

Micro-Optical Pyrometers

A new instrument which permits measuring the temperatures of very small objects such as incandescent lamp filaments, etc., and for laboratory and scientific research work has been developed by the Pyrometer Instrument Co. Bulletin Kc-37.

Defi Rust

Analysis and descriptive notes of nine types of heat and corrosion resisting steels made by Rustless Iron and Steel Co. are contained in a handsome folder. Bulletin Ha-169.

Hydryzing

Hydryzed work is completely described in recent literature released by Lindberg Engineering Co. Points out advantages in particular applications. Bulletin Bc-66.

Heroult Furnace

Revised and expanded to include modern major innovations in the construction and operation of the Heroult electric furnace, the latest edition of the American Bridge Co.'s Heroult Electric Furnace Bulletin is available. Bulletin Bb-124.

Seamless Tubes

Prepared by the Timken Steel and Tube Division of Timken Roller Bearing Co. is a "Guide for Users of High Temperature Steels," which presents technical data relating to the various properties of Timken seamless tubes. Bulletin Bb-71.

Wide-Strip Pyrometer

Complete information on the new Bristol Multiple Record Wide-Strip Pyrometer can be obtained through the Bristol Company. Gives up to 8 temperature records on the same chart. Bulletin Ac-87.

Colmonoy

The high resistance to wear and corrosion which distinguishes Colmonoy alloys and overlay metals is explained in a 4-page catalog released by Wall-Colmonoy Corp. Bulletin Bc-85.

Tellurium Coppers

A comparison of Chase Tellurium Coppers with other alloys is contained in a new folder published by the Chase Brass & Copper Co. Bulletin Kc-59.

Annual Index

The Annual Index of the Copper Alloy Bulletin published regularly by the Bridgeport Brass Company is now made available through this company. Bulletin Kc-163.

Core Baking Ovens

Helpful facts for producing better cores for the foundry are contained in an attractive 8-page folder printed by The Paul Maehler Co. Bulletin Kc-159.

Ni-Cr Castings

Compositions, properties, and uses of the high nickel-chromium castings made by The Electro Alloys Co. for heat, corrosion and abrasion resistance are concisely stated in a handy illustrated booklet. Bulletin Fx-32.

Mo-W High Speed

J. V. Emmons, metallurgist for Cleveland Twist Drill Co. and largely responsible for the development of the molybdenum-tungsten high speed steels known as Mo-Max, has prepared a general description of these new steels. Bulletin Ka-103.

Lubrication

Intensive research which completed important improvements in the field of heavy-duty gear and bearing lubrication is tabulated in a new 12-page illustrated bulletin just released by D. A. Stuart Oil Co., Ltd. Bulletin Lb-118.

Hardness Testing

A 4-page folder which has as its purpose "to give you an idea of how practical a thing it is to make hardness tests on raw stock or fabricated metal parts in all plants where metal is worked, and to suggest something of the necessity for making such tests, or at least their importance" is available through the Wilson Mechanical Instrument Co. Inc. Bulletin Fb-22.

Globar Elements

Globar Pin Type Non-Metallic Electric Heating Elements and Terminal Rods and Globar "AT" Type Non-Metallic Electric Heating Elements are explained and illustrated in two recent booklets issued by the Globar Division of the Carborundum Company. Bulletin Lb-25.

Cutting Oils

An interesting new booklet "Metal Cutting Lubrication—In Theory and Practice" has just been made available by Cities Service Oil Co. Bulletin Ec-113.

Foundry Sand

A pamphlet recently issued on TAM Foundry Zircon Sand and TAM Zircon Flour contains detailed information on these products of the Titanium Alloy Mfg. Co. Bulletin Hc-90.

Tremendous Trifles

Another of International Nickel's instructive folders on Monel Metal covering actual case studies of the use of Monel is now available. Bulletin Lc-45.

Controlled Combustion

Direct Fired Air Heaters which make possible Controlled Combustion and permit wider range in oven and furnace operation are explained in a 4-page folder by the Despatch Oven Co. Bulletin Lc-123

Optical Pyrometer

The first industrial Optical Pyrometer to use the potentiometer method of measurement is featured in an interesting and instructive booklet published by Leeds & Northrup Co. Bulletin Lc-46.

Machining Data

A new chart giving the correct grade of Kennametal for machining 21 types of metals, with recommended cutting speeds, has just been made available by McKenna Metals Co. Bulletin Lc-238.

Burners

New and up-to-date bulletins by Eclipse Fuel Engineering Co. covering many types of burners as well as their complete listing of products are now available. Bulletin Lc-226

Tocco Process

The marvel of all heat treaters—the Tocco Process of Induction Hardening—is fully described in a colorful folder by the Ohio Crankshaft Co. Bulletin Lc-145.

Arc Welders

The three types of Marquette a.c. arc welders, in ranges up to 250 amps., are illustrated and described in this folder. The machines feature streamlined design and 15 taps on the front panel which provide a wide choice of welding amperage. Marquette Mfg. Co., Inc., Minneapolis. Bulletin Ec-216.

Heat Resisting Castings

A 4-page folder on Pyrasteel, heat resisting castings, that shows applications of special alloy steels and their analyses, also information on welding alloy steels, is available through Chicago Steel Foundry Co. Bulletin Cb-184.

Insulation

A 32-page catalog containing specific information on all of the sheet, block and pipe insulations developed by the Johns-Manville Company is now available through that company. Bulletin Fb-100.

Lectromelt Furnaces

The story behind lectromelt furnaces is well told in this 48-page booklet issued by the Pittsburgh Lectromelt Furnace Corporation. Tells of development and recent improvements. Bulletin Db-18.

Ampco Data

An interesting bound volume of Ampco Engineering Data Sheets which give performance records and details about the six grades of Ampco Metal is now available. Bulletin Fc-175.

Model "Y"

The Sentry Model "Y" electric furnace, using the Sentry Diamond Block method of heat treatment, provides exceptional quality high speed steel hardening at minimum production cost. The furnace is described in Bulletin Oy-114.

Multi-Point Pyrometer

The Alnor Rectangular Type Pyrometer, designed to provide a rugged moderately priced instrument with multi-point switch, is described in a release by the Illinois Testing Laboratories, Inc. Bulletin Dc-180.

Vanadium Steel

Latrobe Electrite Vanadium High Speed Tool Steel is described in literature released by the Latrobe Electric Steel Co. Bulletin Kb-208.

Prevention of Rust

"Proof of Results" is the apt title of a new booklet issued by Dearborn Chemical Co. Dozens of photographs, supported by an interesting text, show how No-Ox-Id keeps steel from rusting. Bulletin Mr-36.

Stainless Steel Stock List

A handy 16-page Stocklist showing size of Rezistal sheets, bars and welding rods carried in Crucible's Mills and 26 branches is offered by the Crucible Steel Company of America. Bulletin Kc-56.

Electric Furnaces

An 8-page booklet on high frequency heating for forging, hardening, brazing, etc., with general description of equipment has been issued by the Ajax Electrothermic Corp. Bulletin Kc-41.

Lubricant Economy

Extreme pressure treated, high film strength lubricants, known as Houghton's Sta-Put series, grouped and graded according to industrial machinery applications, are described in a well-illustrated booklet entitled "Less Oil—Less Often." E. F. Houghton & Co. Bulletin Ab-38.

Firestone

A story of the origin and history of Buckeye silica firestone makes an interesting preamble to a complete technical discussion of the properties and applications of this refractory. Cleveland Quarries Co. Bulletin Ka-176.

Ledloy

A new cold drawn steel developed by Wyckoff Drawn Steel Company under the name of "Ledloy" is described in a bulletin just issued. Available in all standard S.A.E. analyses, this steel has interesting advantages. Bulletin Kb-99.

Carburizing Compounds

Aerocarb Carburizing Compounds, the new development of the American Cyanamid & Chemical Corp., are described in Bulletin Dc-148.

Instruments Range

From molten metal to motor cars—a folder by Foxboro Co. graphically illustrates the wide range of applications for Foxboro instruments in all production and processing operations. Bulletin Id-21.

Alloy Castings

Calite Chromium-nickel alloy castings for furnace roller rails are pictured and described in a release by the Calorizing Co. Bulletin Ec-26.

Super Refractories

A catalog of Chas Taylor Sons Co. is replete with useful data on P. B. Sillimanite refractories for use up to 3000° F. in electric furnace roofs and linings, induction furnaces, crucible furnaces, fuel-fired hearths, piers and linings, burner blocks, etc. Bulletin Ec-218.

New Copper Alloy

Mallory 333 metal, a new copper-chromium-lithium alloy, described as combining hardness with high conductivity, is useful for welding electrodes and other applications, according to a bulletin of P. R. Mallory & Co. Bulletin Ec-220.

New High-Strength Steel

This little book gives facts and figures on DYN-EL, a new high strength, flat rolled steel claimed to have unusual resistance to fatigue, impact and corrosion. Complete fabricating and design properties and table of sizes and weights are included. Alan Wood Steel Co. Bulletin Ec-225.

Duriron

A new bulletin on steam jets, ejectors, tank outlets and spray nozzles has just been issued by the Duriron Co. Illustrated with photographs and dimension drawings of the equipment. Bulletin Gc-152.

Refining Slag

Purite made by Mathieson Alkali Works is stated to reduce metal shrinkage and casting losses and to improve general quality by forming a protecting and refining slag. Composition, general instructions for use, and directions for use with various furnaces are given in Bulletin Ec-224.

Bimetal

Interesting facts about thermostatic bimetal are contained in an extremely well-prepared book by W. M. Chace Valve Co. Applications, forms available, and how the material acts in temperature control devices are given. Bulletin Ec-232.

Plastic Testing

Modern plastic material testing machines have been completed by Tinius Olsen Testing Machine Co. and are described in a colorful booklet just released. Bulletin Ec-147.

Furnace Experience

Facts developed through 32 years of engineering and building practically every type of industrial fuel equipment can be obtained through Flinn & Dreffein Co. Bulletin Bc-82.

Vanadium Castings

A 24-page bulletin well illustrated with more than 20 photographs contains a complete description of the properties and applications of a number of vanadium alloy steels for castings where high strength is required without excessive weight or high cost. Vanadium Corp. of America. Bulletin La-27.

Stainless Electrodes

An attractive 16-page booklet printed in aluminum contains interesting facts about stainless electrodes, with particular attention to McKay "Certified" electrodes. The McKay Co. Bulletin Hc-248.

Architectural Shapes

Amply illustrated by excellent photographs and drawings of extruded architectural shapes, a very well made up bulletin on copper, brass, bronze and nickel silver architectural shapes and sheets is available from Revere Copper and Brass, Inc. Bulletin Id-239.

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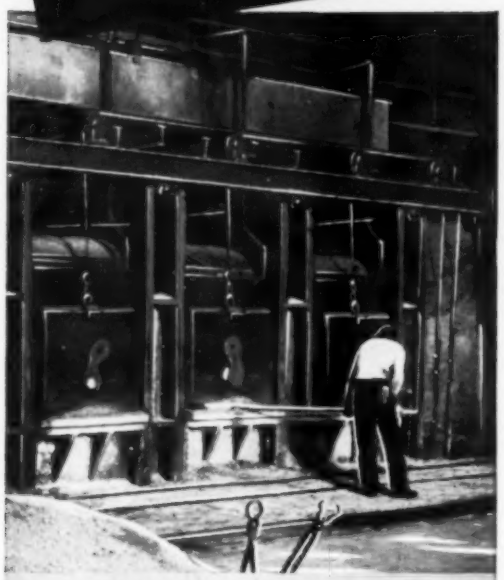

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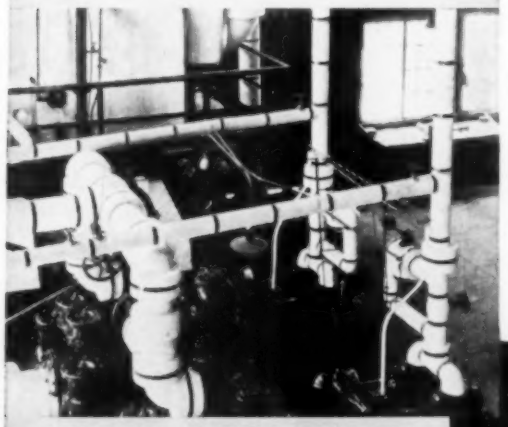

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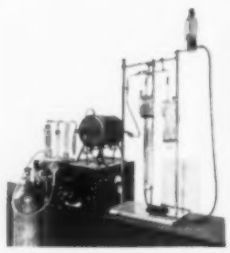

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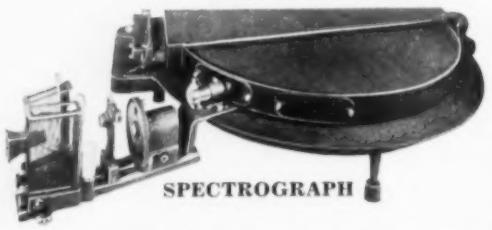

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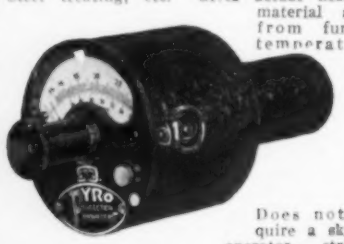

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(Continued from page 762)

crucible. The crystalline appearance of the surface is due to a very thin, non-adherent film of nickel oxide that arose to the surface of the liquid during the melt.

Finally, Fig. 6 (page 762) shows the appearance of a 25% nickel austenite, after prolonged etching in boiling ammonium persulphate. This reveals within the grains the initial dendritic network, but also produces stripes or ripples, which give an unaccustomed eutectic appearance to certain grains.

It may be seen, therefore, that when etching methods producing colored films are used, peculiarities that may be the source of errors in interpretation may well be superposed on the micrographical characteristics revealed by ordinary etching methods.

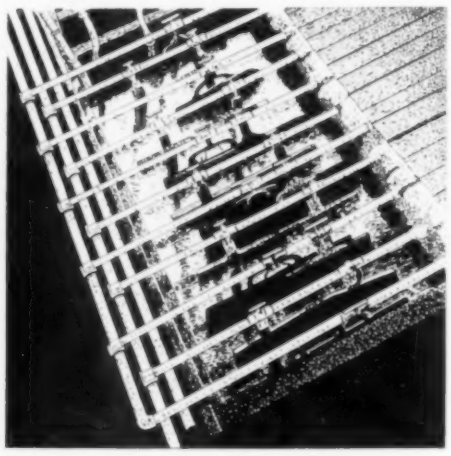
ALBERT M. PORTEVIN

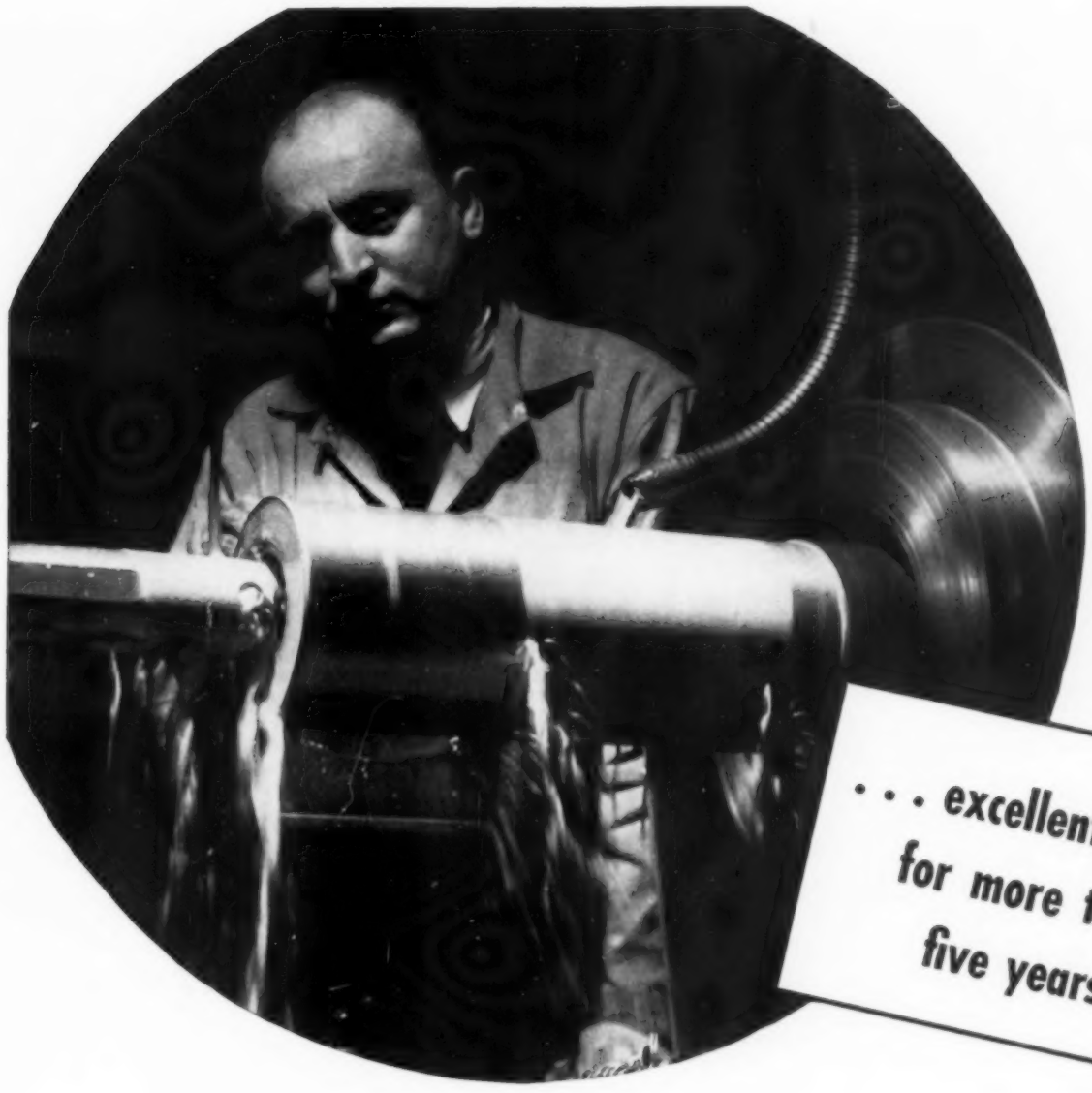
Electroplating and Finishing
(a correction)

IN the review of electroplating and finishing published in the October issue of METAL PROGRESS, page 383, the writer stated that there was some question about the continuation of the research work being carried on at the Bureau of Standards under the auspices of the American Electro-Platers' Society.

It has since been decided that the work on the development of specifications for electroplates on non-ferrous metals will be completed and published. In addition, plans are under consideration for further work on some new problems.

ADOLPH BREGMAN





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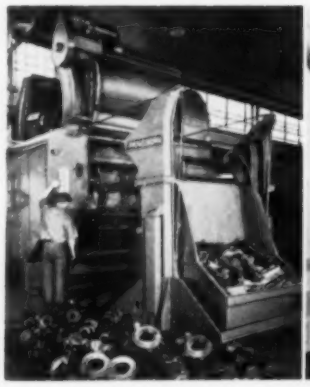

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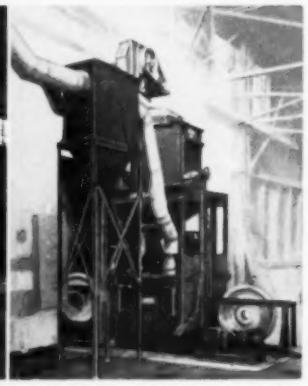

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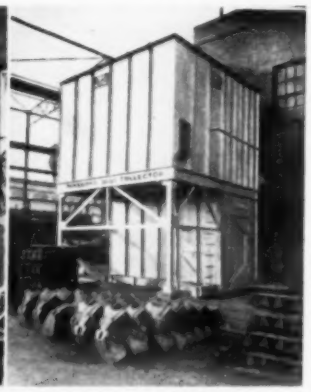

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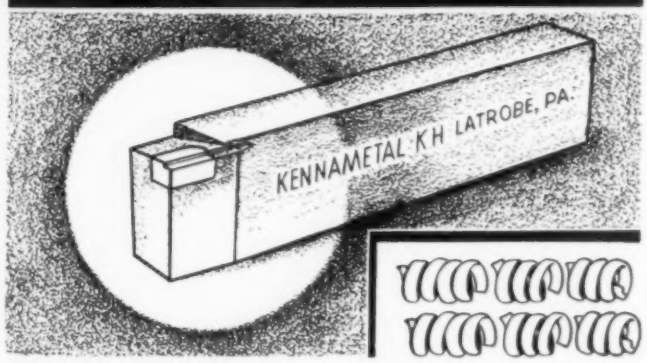

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How Calcium-Manganese-Silicon Improves Steel Castings . . .

CALCIUM-MANGANESE-SILICON combines three powerful deoxidizers in one alloy. It is more effective as a deoxidizer and scavenger of steel than separate alloys containing these elements. Added to cast steel in the ladle it dissolves readily in the molten metal, cleanses the steel rapidly and thoroughly, removes dissolved gases, and forms a low-melting, fluid slag. Pinholes and porosity are minimized. Clean, sound castings with improved ductility are the result.

Ask to have one of our metallurgists call and explain further how calcium-manganese-silicon as a ladle deoxidizer improves steel castings. He will gladly help make your use of this and other "Electromet" ferro-alloys profitable. Electro Metallurgical Company, Unit of Union Carbide and Carbon Corporation, 30 East 42nd Street, New York, N. Y. In Canada: Electro Metallurgical Company of Canada, Limited, Welland, Ontario.

Items of Interest about other "Electromet" Ferro-Alloys

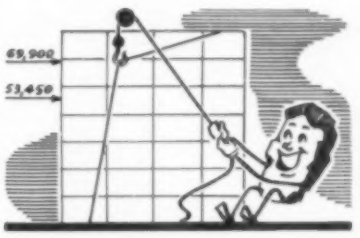
Zirconium Improves Green Sand Castings — Green sand castings treated with zirconium show fewer pinholes, smaller grain sizes and less segregation of impurities at the grain boundaries. This produces a uniform texture free from hard spots, and improves machinability.

Calcium-Silicon Simplifies Pouring of Steel Castings — Calcium-silicon used as a ladle deoxidizer cleanses the steel and increases its temperature and fluidity. Steel treated with calcium-silicon flows freely right to the end of the pouring period. This simplifies pouring practice.

Silico-Manganese Helps Make Clean, Uniform Steel at Lower Cost — Silico-manganese deoxidizes steel quickly and thoroughly, leaving it clean and ready for tapping in 10 to 15 minutes. This rapid deoxidation, together with the low carbon content of silico-manganese, saves furnace time and permits close control of final analysis. Thus clean, uniform steel is obtained at lower cost.

Medium-Carbon Ferromanganese Shortens Furnace Time — When medium-carbon ferromanganese is used instead of standard ferromanganese in the production of low-carbon steel, oxidation of the bath need not be so severe because medium-carbon ferromanganese adds about one-sixth as much carbon to the bath as the standard grade. As a result, the heat can be made in from one-quarter to one-half hour less time.

Vanadium Increases Strength and Toughness of Nickel-Steel Castings — The averaged values of a series of tests showed that the addition of 0.10 per cent vanadium to a nickel steel raised the yield-point strength from 53,450 to 69,900 lb. per sq. in., and increased the Izod impact from 35.5 to 74.3 ft-lb. Elongation and reduction of area were also slightly increased.



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If you want more information about these and the many other "Electromet" ferro-alloys and metals and the service that goes with their purchase, write for the booklet, "Electromet Products and Service."

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Trade-Mark
Ferro-Alloys & Metals

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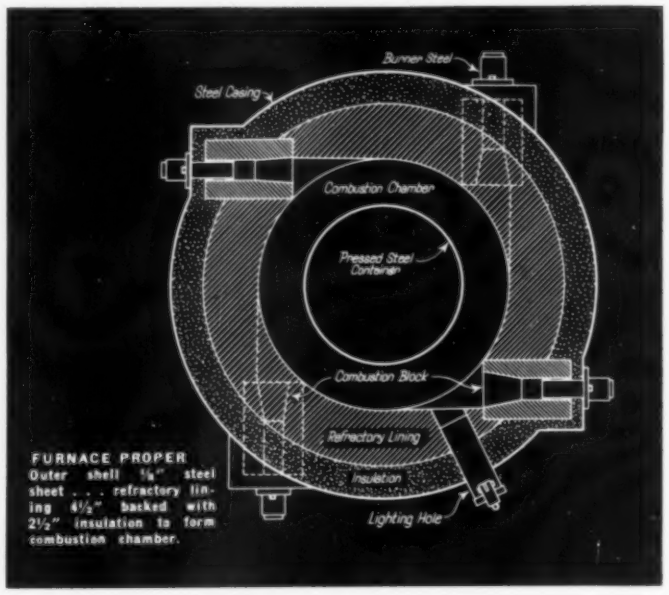
McKee Burners used in conjunction with properly designed, preburned combustion blocks insure satisfactory operation.

FLUE BOX

Old style cast iron flue has been replaced with refractory lined flue box.

BOTTOM

Heavy top and bottom castings are of cast iron. Expansion ring on top casting eliminates infiltration of lead or salts into furnace combustion chamber.



FURNACE PROPER
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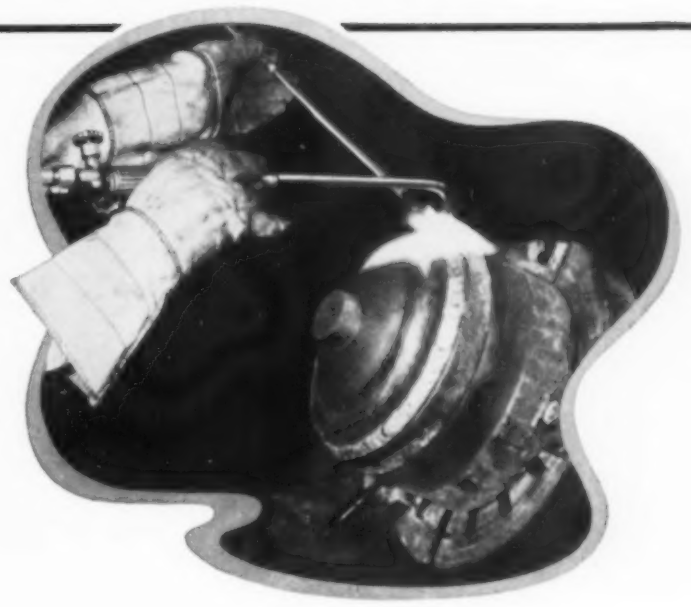

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The burning in of mold and facing sand where metal is poured at abnormally high temperatures is a constant source of increased cleaning costs. This is particularly true of highly alloyed steel castings—and is accentuated where the casting has fine detail such as internal threaded cores.

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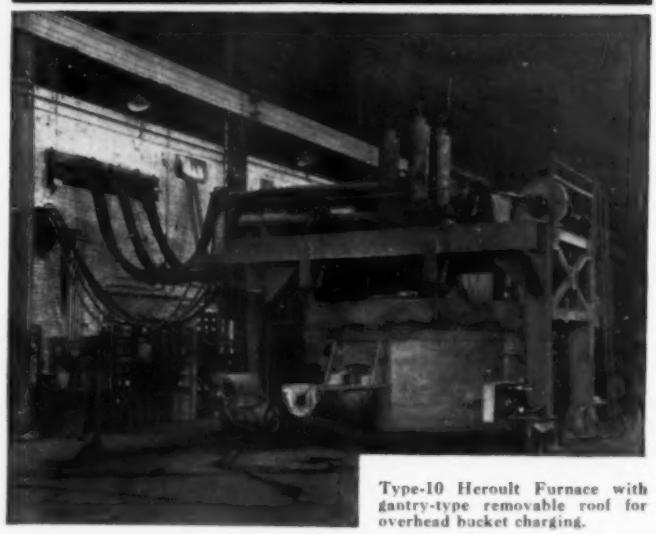

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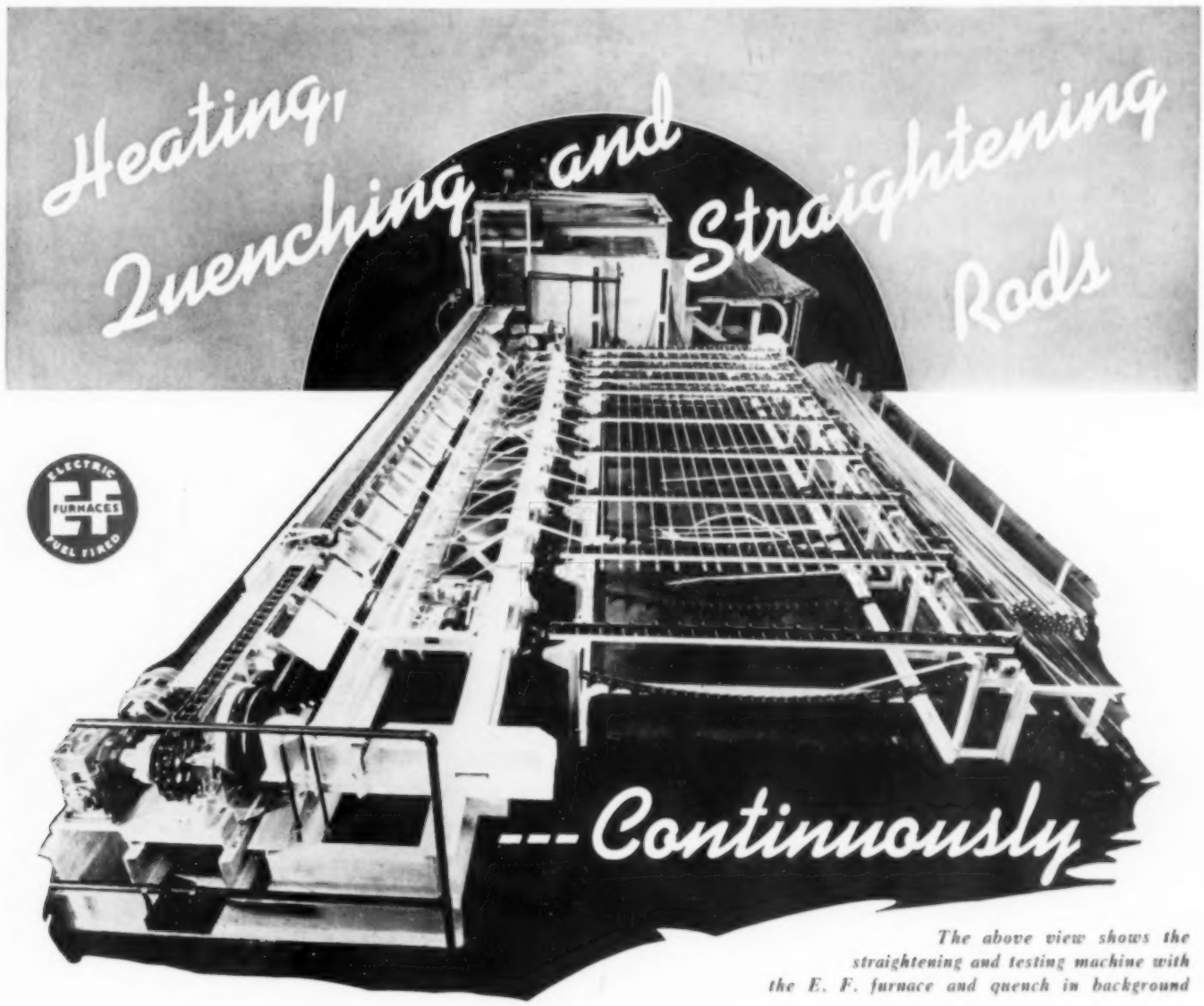

The above view shows the straightening and testing machine with the E. F. furnace and quench in background

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Emil Gathmann, President

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